VOL. XII, No. 3 MAY, 1946

PROCEEDINGS

OF THE

HAWAIIAN ENTOMOLOGICAL SOCIETY

FOR THE YEAR 1945

HONOLULU, HAWAII

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Krauss, N. L. H.
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McBride, O. C.
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Murakami, Kenneth
Nishida, Takiyuki
Pemberton, C. E.
[2]Perkins, R. C. L.
Rosa, J. S.
Sakimura, K.
Schmidt, Carl T.
Schmidt, Helen B.
Suehiro, Amy
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[1]Worcester, D. J.
Zimmerman, E. C.

All correspondence should be addressed to the Secretary, Hawaiian Entomological Society, 1527 Keeaumoku St., Honolulu 4, Hawaii, from whom copies of the Proceedings may be obtained.

[1] Corresponding Member.
[2] Honorary Member.
[3] To serve in the absence of N. L. H. Krauss.

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PROCEEDINGS
OF THE
Hawaiian Entomological Society

Editor Emeritus, O. H. Swezey

VOL. XII, No. 3 FOR THE YEAR 1945 MAY, 1946

JANUARY 8, 1945

The 469th meeting was held at the H.S.P.A. Experiment Station on Monday, January 8, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Fullaway, Jensen, Nishida, Pemberton, Rosa, Sakimura, Schmidt, Swezey, Van Zwaluwenburg, Williams and Zimmerman.

Visitors: Messrs. C. T. Parsons and F. G. Werner.

NOTES AND EXHIBITIONS

Psoroptes communis Fürstenberg—Mr. Pemberton reported the presence of quantities of this scab mite in the ears of a rabbit. The mites were collected by a member of the U. S. Army on Oahu, December 26, 1944. This is the first record of this sarcoptid in the Territory.

An aphid new to Hawaii—Mr. Van Zwaluwenburg called attention to the description by E. O. Essig of *Cerosipha californica* n.sp.[1] (Hilgardia, **16** [4]: 177-181, fig. 1, July 1944) from California and Oahu. It was first found at Salinas, Calif., on roots of slightly wilted seedlings of guayule (*Parthenium argentatum* Gray). Later it was found on roots of potatoes at Bakersfield, and (alates) on leaves of French prune at Davis, Calif. In checking alate specimens of what he provisionally considered to be *Vesiculaphis caricis* (Fullaway), collected September 9, 1940, on tomato by W. C. Look at the "Waipaha" [Waipahu] school garden, Prof. Essig found them to be this "guayule aphid".

Achaea janata (Linn.)—Mr. Sakimura reported finding three specimens of this agrotid moth at light immediately after the Society's last meeting in December at which the species was first re-

[1] This insect was later shown by Prof. Essig to be a synonym of *Cerosipha subterranea* (Mason), a species widely distributed in the continental United States from Maryland to California. See p. 468 [Ed.].

corded locally. That the moth has suddenly become fairly numerous was attested by reports of several other members who have collected it recently.

Hambletonia pseudococcina Compere—Dr. Schmidt reported the recovery of this encyrtid parasite of *Pseudococcus brevipes* (Cockerell) from material collected recently at Baldwin Packers, west Maui; it had not previously been reported from this region. The parasite was imported from South America during the period from 1935 to 1937.

FEBRUARY 12, 1945

The 470th meeting was held at the H.S.P.A. Experiment Station on Monday, February 12, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Faxon, Fullaway, Jensen, Keck, Marlowe, Murakami, Pemberton, Rosa, Swezey, Van Zwaluwenburg, Williams and Zimmerman.

Visitors: Messrs. A. S. Johnson, J. D. Maple and E. M. Miller.

Mr. Fullaway nominated Mr. Douglas J. Worcester for membership in the Society.

NOTES AND EXHIBITIONS

Leptomastix dactylopii Howard—Mr. Fullaway exhibited specimens of this aphelinid parasite of mealybugs recently found established at the Territorial plant nursery in Honolulu, a new record for the Islands. This is an accidental introduction from California, and Mr. Fullaway's specimens came from a mixed infestation on soybeans and eggplant of *Phenacoccus gossypii* Townsend & Cockerell and *Pseudococcus kraunhiae* (Kuwana).

Backyard insect census—Dr. Swezey reported progress on the insect census of his garden and residence on Lanihuli Drive, Manoa Valley, Honolulu. Since his last report (Proc. Haw. Ent. Soc., 11: 277, 1943) he has added about 40 names, so that now the total is 293, distributed in the following orders: Hymenoptera 57; Diptera 41, Coleoptera 63; Lepidoptera 43, Heteroptera 11; Homoptera 28; Orthoptera 10; Dermaptera 2; Blattaria 9; miscellaneous 29.

Achaea janata (Linn.)—Dr. Swezey reported that R. E. Doty had brought him a specimen of this immigrant agrotid collected at light on Mt. Tantalus, February 5. Dr. Swezey also reported the capture of two of these moths at light on February 11 at his house in Manoa Valley.

Identity of the new immigrant parasite of cockroach eggs—Mr. Zimmerman reported that Dr. Harold Compere had identified the new encyrtid parasite of cockroach oöthecae as *Comperia falsicornis*

(Gomes). The species was described from the Federal District of Brazil, as *Comperia merceti* var. *falsicornis* Gomes (Bol. Escola Nac. Agro., 2: 30-37, 1942). Mr. Zimmerman previously reported upon the successful work of this parasite on oöthecae of *Supella supelectilium* (Serville) at a meeting of the Society in 1943 (Proc. Haw. Ent. Soc., 12: 20, 1944). It is the same species as that recorded by Mr. Pemberton (Proc. Haw. Ent. Soc., 11: 139, 248, 1942) as probably *Metaphycus* sp.

Caenis sp.—Dr. Jensen exhibited a mayfly he had collected in Gilmore Hall, University of Hawaii, Manoa, Honolulu, on the night of January 30, 1945. The specimen apparently had been attracted to the light and entered the room through an open window. This record represents an extension in distribution of this order from Pearl City to Manoa Valley. Other specimens of this ephemerid were first collected in Hawaii in July 1944, in a light trap operated by Lt. Wm. M. Herms, U.S.N.R., at Pearl City, Oahu. According to Dr. Swezey, who identified the Pearl City material, the genus *Caenis* Stephens is cosmopolitan; the adults of the family Caenidae, to which it belongs, are characterized by having very few cross veins and no hind wings.

Blapstinus dilatatus LeConte—Dr. Jensen exhibited specimens of this tenebrionid beetle collected at Koko Head, Oahu, September 20, 1944. Adults were reported injuring watermelon plants, chewing the vines two or three feet from the base of the plant, thus causing the vines to wilt. The species is common in southern California where it has been recorded girdling young pepper plants. Three specimens were collected earlier by Messrs. Look and Nishida in soil at Waialua, Oahu, June 16, 1944. The specimens were determined by Dr. E. C. Van Dyke; earlier local identifications of this species had been only tentative.

A gynandromorph *Contarinia*—Dr. Jensen exhibited a slide mount of an unusual gynandromorph which occurred among adults of a cecidomyiid, *Contarinia* sp., reared from flower buds of "pikake" (*Jasminum sambac*). A single specimen was found which bears female antennae, but male genitalia. The characters of the antennae of the sexes are as conspicuously different as are the genitalic characters. The pikake buds were collected by Dr. Jensen near Fort Ruger, Honolulu, January 11, 1945. Approximately 75 per cent of the living buds were infested with eggs, larvae or both.

MARCH 12, 1945

The 471st meeting was held at the H.S.P.A. Experiment Station on Monday, March 12, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Fullaway, Jensen, Nishida, Pemberton, Rosa, Swezey, Tanada, Van Zwaluwenburg, Williams and Zimmerman.

Visitors: Messrs. O. H. Edinger, Wm. D. Field, J. E. Webb, Jr., and F. N. Young.

Mr. Douglas J. Worcester was unanimously elected to membership.

NOTES AND EXHIBITIONS

Tribolium castaneum (Herbst)—Mr. Van Zwaluwenburg called attention to a paper by Newell E. Good (U.S.D.A. Tech. Bul. **498**, "The Flour Beetles of the Genus Tribolium", 1936) in which it is shown that the red flour beetle, a cosmopolitan pest, should be known as *Tribolium castaneum* (Herbst), and not as *T. ferrugineum* (Fabr.). Two species were described by Fabricius under the name *Tenebrio ferrugineus*. The first one so named, in 1781, is a cucujid, on the authority of Waterhouse and others; the same name used in Fabricius' 1787 description, is a homonym, and cannot stand.

Hyposoter bred from *Achaea*—Mr. Van Zwaluwenburg reported that one of three larvae of the recently established agrotid, *Achaea janata* (Linn.), collected March 8 at Waialua mill, Oahu, on the weed known locally as *Euphorbia bifida* Hooker & Arnott, yielded a cocoon of the ichneumonid, *Hyposoter exiguae* (Viereck), two or three days later. Earlier the same week, Mr. Rosa observed an adult *Hyposoter* in a jar containing *Achaea* larvae collected at Waianae, Oahu.

New geometrid moth—Mr. Pemberton discussed the status of an unidentified geometrid[2] recently found widely distributed over Oahu. Over a dozen moths were first caught in a light trap operated by the Navy at West Loch, Pearl Harbor, during August 1944. Then, early in February 1945, Dr. Williams found some strange caterpillars feeding on foliage of *Nicotiana glauca* in his garden in Honolulu. Reared to adults, they proved to be the same as the moths caught at Pearl Harbor. Examination by Dr. Swezey showed the species to be new to Hawaii. Field surveys by H.S.P.A. entomologists resulted in the recovery of the moth during February over most of this island, and on Mt. Tantalus to an elevation of 1,600 feet. Larvae were found feeding on the leaves of 29 different plants, and in some cases causing considerable defoliation. Many of the host plants are ornamental flowering trees, and several are important forage trees and shrubs. The list embraces 14 different plant families, with Leguminosae especially favored. It is assumed that the insect came to Oahu in an airplane.

[2] Subsequently identified as *Anacamptodes fragilaria* (Grossbeck), an insect native to southern California [Ed.].

Achaea janata (Linn.)—Mr. Pemberton also discussed the result of surveys made to determine the present distribution and host plants of this large agrotid, first seen in Hawaii in December 1944, when Dr. Williams collected an adult at the H.S.P.A. Experiment Station, Honolulu. Caterpillars were found in quantity at Waianae and Ewa, Oahu, feeding on, and completely defoliating, castor oil plant (*Ricinus communis* Linn.). It was also found on the common weed, *Euphorbia bifida* Hooker & Arnott and on the forage plants *Leucaena glauca* Bentham and *Desmanthus virgatus* Willdenow; a single larva was taken on a partially eaten leaf of a fern (*Polypodium* sp.).

Because this moth is widespread from India through the Malay Archipelago to New Guinea, Australia and many of the South Pacific islands, and has been found in airplanes arriving at Honolulu, it is assumed to have reached Oahu by plane. Mr. Bianchi stated that he had found the eggs of *Achaea,* chiefly on leaves of *Ricinus* and *Euphorbia,* widespread over Oahu. The eggs are laid singly, and all that he had collected yielded adults of *Trichogramma minutum* Riley.

Enarmonia walsinghami (Butler)—Dr. Swezey reported having reared several of this tortricid moth from dead, malformed, small branches of *Acacia koa* sent in by C. J. Davis, a ranger at the Hawaii National Park, Hawaii. The material was collected at an elevation of 6,700 feet on the Mauna Loa trail, February 2, 1945. This is the same moth Dr. Swezey previously reared from dead koa twigs on Mt. Tantalus and Mt. Olympus on Oahu, and from koa rust galls on Maui. Mr. Davis found the larvae boring in the living wood where the twig or branch was malformed from the effects of rust galls or something similar. Thus, it is shown that it does not confine itself to dead wood as a diet, as many Hawaiian moths are known to do. This is similar to Mr. Davis' observations of *Neotermes connexus* Snyder feeding in living koa branches, a sample of which he sent in early this year. It was collected in the Kipuka Puaula at the Hawaii National Park, and showed considerable excavation by termites in the heart wood of a branch three to four inches in diameter, which was still alive. Usually this termite feeds in dead branches and trunks of the native forest trees.

Podagrion mantis Ashmead—Dr. Swezey reported that in determining for Mr. Sakimura insects caught in wind traps in the pineapple fields of the Kunia, Oahu, region, he found specimens of this callimomid parasite of mantis eggs, dated April 27, 1943, May 4, 1943, July 13, 1943 and August 17, 1943. The first two dates are prior to the first record reported from Molokai by Mr. Krauss, May 31, 1943 (Proc. Haw. Ent. Soc., **12**: 92, 1944).

Phygadeuon sp.—Dr. Swezey reported this ichneumonid parasite of syrphids was also found in Mr. Sakimura's material, collected

February 8, 1944. It is apparently its first record from Oahu. It was first collected in July 1932, at the Hilo Sugar Co., Hawaii, by Dr. Williams (Proc. Haw. Ent. Soc., **8**: 233, 1933).

Solierella rohweri (Bridwell)—Dr. Williams exhibited a female of this larrid wasp caught by Mr. Sakimura in a wind trap at Kunia, Oahu, August 8, 1944. The head of this insect was quite abnormal, since there were no ocelli and the eyes converged very strongly at the vertex instead of having their inner margins nearly parallel.

Cerosipha subterranea (Mason)[3]—Mr. Zimmerman reported that Mr. Essig had informed him that the aphid recently found on Oahu, and described as the "guayule aphid," *Cerosipha californica* Essig (Hilgardia, **16** [4]: 177, fig. 1, 1944) has been found to have been described previously by Mason (Proc. Ent. Soc. Washington, **39** [6]: 166, fig. 1, 1937) as *Rhopalosiphum subterraneum,* and that the new name combination *Cerosipha subterranea* (Mason) should be applied to the species.

Ilburnia ipomoeicola (Kirkaldy)—For Mr. Look, Mr. Fullaway reported the finding of this delphacid, the sweet potato leafhopper, near Kilauea, Hawaii. Eggs of this insect were also found in the stems of the vines.

APRIL 9, 1945

The 472nd meeting was held at the H.S.P.A. Experiment Station on Monday, April 9, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Carter, Faxon, Fullaway, Hadden, Holdaway, Jensen, Nishida, Pemberton, Sakimura, Swezey, Tanada, Van Zwaluwenburg, Williams and Zimmerman.

Visitor: Mr. W. W. Wirth.

Mr. Fullaway and Dr. Williams presented the following resolution:

Lehr Artiman Whitney

Whereas, in the death of Lehr Artiman Whitney on February 21, 1945, the Hawaiian Entomological Society has lost one of its oldest and most cherished members, therefore

Be it resolved that the Society record its great and grievous loss with due expression of its appreciation of the interest of its distinguished member in the affairs of the Society which he served as Vice-President in 1929, and as President in 1930, and in the Proceedings, to which he made many valuable contributions in the way of papers, notes, etc., embodying his observations and recording other scientific data.

[3] See p. 463.

With the adoption of the above resolution the Secretary is requested to send a copy of the same to the surviving brothers of the deceased with a note expressing the deep sympathy of the members of the Society in their bereavement.

NOTES AND EXHIBITIONS

Beetles in mango twigs—Mr. Fullaway exhibited a collection of beetles found feeding in living twigs of mango on Kauai by Stephen Au; they were determined by Dr. Swezey as follows: (?) *Lyctus brunneus* (Stephens), 2; *Xyleborus* sp., 1; and several *Stephanoderes* sp.

Parasites of *Achaea janata* (Linn.)—Mr. Bianchi exhibited several puparia of *Eucelatoria armigera* (Coquillett) and some adults of *Chaetogaedia monticola* (Bigot) which had issued from pupae of *Achaea janata*. One *Chaetogaedia* had issued on April 4 from a pupa reared in the laboratory on *Ricinus* at Manoa Valley on February 14. The others had issued from material collected at Ewa during the first part of March. The *Eucelatoria* puparia had been found within skins of *Achaea* caterpillars collected on *Ricinus* plants growing along the Waianae road near Ewa on March 31.

Stegania sp.[4]—Mr. Bianchi stated, for Mr. Rosa and himself, that on March 19, at Waianae, Oahu, they had discovered egg masses of the new geometrid (*Stegania* sp.) under bark on the trunks of kiawe (*Prosopis chilensis*). Eggs had not been found in the field before, although the moth's manner of oviposition in the laboratory had indicated the probability that they would be found eventually under bark. Mr. Bianchi pointed out that in such a location the eggs would be almost completely protected from attack by *Trichogramma minutum* Riley, and said that out of many field-collected egg masses, totalling probably over 1,000 eggs, not a single parasite had issued, although in the laboratory *Trichogramma* had been shown by Dr. Swezey to parasitize the eggs readily.

Ephialtes hawaiiensis (Cameron)—Mr. Bianchi exhibited specimens of this ichneumonid which he and Mr. Rosa had reared in the laboratory on pupae of *Stegania* sp. Numerous *Ephialtes* wasps had been observed at Waianae on March 19 hovering over soil which thinly covered many pupae and prepupae of *Stegania;* from this behavior it was surmised that the wasps would parasitize the pupae. This proved to be the case in the laboratory, but it is apparently a rare occurrence in the field, for not one *Ephialtes* was obtained from about 150 *Stegania* pupae collected at Waianae. Mr. Bianchi stated that *Ephialtes* in glass tubes will readily sting the pupae, the prepupae, and even the larvae of *Stegania,* but that only a small proportion of the attacks results in successful oviposition. The wasps were also observed in the laboratory to attack the pupae

[4] This is the insect subsequently identified as *Anacamptodes fragilaria* (Grossbeck) [Ed.].

of *Achaea janata* (Linn.), but with as yet undetermined effectiveness. The wasps exhibited had emerged in about 16 days from the time of oviposition, a remarkably short time for a parasite of their size. *E. hawaiiensis,* according to data in the H.S.P.A. collection, has been reared previously from pupae of *Pyroderces incertulella* (Walker), *Archips postvittanus* (Walker), *Euhyposmocoma ekaha* (Swezey), *Capua reynoldsiana* Swezey, *Capua cassia* Swezey and *Cryptophlebia* sp., all native microlepidoptera.

Anaphothrips obscurus (Müller)—Mr. Bianchi spoke of a mild infestation of this thrips on sudan grass grown for experimental purposes in the hothouse at the H.S.P.A. Experiment Station. The species was first found in the Territory in the same locality and under the same circumstances in January 1941, and had not been reported again until now.

Notogramma stigma (Fabr.)—On behalf of Mr. Ito, Dr. Carter presented the following: This ortalid fly was recently bred from a dead and rotting stem of *Dendrobium superbum* at Kapahulu, Honolulu. While the owner of the plant suspects that the maggots are casual, the infestation must undoubtedly have occurred after the death of the plant, for this fly has been previously reported breeding in decaying fruits and rotten sugar cane.

Neophyllaphis araucariae Takahashi—Dr. Swezey reported having collected this aphid from young *Araucaria* trees at Foster Gardens, Honolulu, March 31. Dr. H. L. Lyon had called his attention to this slight infestation on young trees in tubs at the nursery. A supply of specimens was collected to send to Prof. E. O. Essig, who desired material of this species. The yellow wingless aphid occurred among the closely approximated leaves at the tips of growing twigs, and would readily escape observation. Four winged forms were obtained. The infestation was discovered by the presence of larvae of the ladybird beetle *Cryptolaemus montrouzieri* Mulsant. These ladybirds, however, were present on account of the coccid *Eriococcus araucariae* Maskell, individuals of which were scattered among the leaves of the terminal twigs. Several of these white coccids were noticed to have exit holes where parasites had issued, and a female parasite was noted in a search among young coccids at the base of the leaves. No doubt this was *Aphycomorpha araucariae* Timberlake, an encyrtid described in Proc. Haw. Ent. Soc., **4**: 227, 1919. This is the first time Dr. Swezey had observed these three insects: *Neophyllaphis, Eriococcus* and *Aphycomorpha.* On the same trees a puparium of the syrphid fly *Ischiodon scutellaris* (Fabr.) was found which had exit holes of the pteromalid parasite *Pachyneuron allograptae* Ashmead. The aphis-feeding ladybird, *Coelophora inaequalis* (Fabr.), was also present. Two lacewing-fly cocoons were also found, from which adults issued April 5 and proved to be *Chrysopa lanata* Banks.

Trichogramma reared from sphingid eggs—Dr. Swezey reported that 11 specimens of *Trichogramma minutum* Riley and one of *T. semifumatum* (Perkins) issued from a sphingid egg found by Dr. Williams on a leaf of *Nicotiana glauca* at his home on Keeaumoku Street, February 14. The egg was undoubtedly that of *Herse cingulata* (Fabr.), though this moth usually oviposits on leaves of several species of *Ipomoea*. Sweet potato vines were growing nearby.

Trichophaga tapetzella (Linn.)—Dr. Swezey reported on two additional records for this tineid moth in Hawaii: 2 specimens from wind trap in pineapple field, Kunia, Oahu, December 2 and 3, 1944 (Sakimura); 2 specimens from light trap, Hickam Field, Oahu, April 8, 1945.

MAY 14, 1945

The 473rd meeting was held at the H.S.P.A. Experiment Station on Monday, May 14, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Faxon, Hadden, Jensen, Keck, Look, McBride, Nishida, Pemberton, Rosa, Sakimura, Swezey, Van Zwaluwenburg, Williams and Zimmerman.

Visitors: Messrs. G. F. Augustson, B. Krafchick, D. B. Langford, J. G. Lewis, F. A. Soraci, J. P. Vinzant and W. W. Wirth.

Dr. Williams nominated Mr. Willis W. Wirth for membership in the Society.

NOTES AND EXHIBITIONS

Draeculacephala sp. a pest of watercress—Dr. Holdaway reported on an insect problem which has become serious in watercress beds since September 1944. The species has been tentatively determined as *Draeculacephala mollipes* (Say).*

Observations were made on watercress beds in the vicinity of Pearl Harbor, March 19, 1945. Inquiries from several growers revealed the following state of affairs: The trouble is present all the year round, but is most serious in the summer months. In September 1944 it became so serious as to reduce production seriously. It has been difficult to secure an exact picture of the injury, since, at the time the observations were made, rotenone dust had been used freely on the watercress and the infestation had been materially reduced. There appear to be two types of injury, the first, a crinkling of the young leaves which reminds one of the injury caused by broad mite (*Hemitarsonemus*) on watercress, although no mites were found. The second type of injury, apparently associated with

* According to Dr. P. W. Oman there are two species of *Draeculacephala* in Hawaii. One, *D. minerva* Ball was first found on Oahu in 1912, and is a southwest United States species. The other, *D. mollipes* (Say) was first taken in Honolulu in 1934, and is a native of the northeastern United States. The above dates are supplied by Mr. E. C. Zimmerman from his unpublished "Insects of Hawaii". [Ed.].

the infestation, is a general yellowing of the older leaves with yellow blotches on the less mature leaves. While this type of injury is apparently associated with an infestation of *Draeculacephala,* since growers report that it ceases to increase when the leafhoppers are controlled by means of rotenone, the injury has the appearance of a disease.

Dr. Holdaway observed *Draeculacephala* in watercress beds at Waipahu in the early part of 1942 when engaged in observations on broad mite on watercress. It would appear that *Draeculacephala* is a common insect of watercress beds, but that not until September 1944 did abundance reach such a level as to be a cause of economic loss.

It is interesting to speculate on why the insect has increased so greatly as to reach economic importance. Two possibilities occur to Dr. Holdaway. First, that particular weather conditions have favored the leafhopper more during the past twelve months than formerly; second, that the increase in watercress production has favored an increase in abundance of the leafhopper. It is not possible, at present, to determine to what extent the first possibility may have operated. Records indicate, however, that production of watercress has increased. Before the war the crop enumerators of the University extension service did not secure records on production of watercress, and so, earlier records are not available. The records for 1943 give a production of 1,003,000 pounds, while in 1944 the production was 1,598,000 pounds—an increase of 50 per cent over the 1943 production which was higher than formerly.

At the time of the observations at Waipahu in 1942, the grower reported that addition of copper sulphate to the irrigation water for control of crayfish appeared to reduce abundance of the leafhopper. Such an observation, if correct, would be in line with observations on control of *Empoasca fabae* (Harris) on the mainland, and *E. solana* DeLong in Hawaii; both of these can be controlled by sprays of Bordeaux. In the case of *E. fabae,* DeLong has demonstrated that control follows absorption of copper by the plant. Inquiries at Pearl Harbor last May revealed that addition of copper sulphate to the extent of 10 to 15 pounds per time, to the head water for control of algae, did not control crayfish and apparently had had little effect on *Draeculacephala.*

Infestation of celery aphid—Dr. Holdaway referred to an infestation of celery aphid, *Brachycolus heraclei* Takahashi, on celery observed by Mr. Nishida and himself at Waialua, Oahu, April 26, 1945. Infestation was building up to an alarming extent on crops nearing maturity. The present shortage of nicotine sulphate for control of aphids and the shortage or unsatisfactoriness of substitutes for nicotine, is resulting in this aphid being a hazard to celery production. Moreover, because celery coming on to the market is often heavily infested with aphids, dealers have sought means of

removing the aphids from the harvested celery before it is placed on sale.

The first record of this species in Hawaii was secured by Dr. Holdaway on celery at Waialua, December 6, 1940. Since then it has been recorded by members of the staff of the Entomology Department of the Hawaii Experiment Station at many places on Oahu (Koko Head, Kaimuki, University campus, Hunnewell Street, Pauoa Road) and also at Lahainaluna School, Maui, and Haleakala homesteads, Olinda, Maui, and at Kamuela, Hawaii. If infestations of celery plants occur when plants are young, serious retardation of the crop may result. The importance of this aphid has increased considerably during recent years, since celery for the local market is now largely produced in Hawaii. The University extension service records an increase of production from 746,000 pounds in 1943 to 2,478,000 pounds in 1944.

A new eriophyid on Hibiscus—Mr. Look reported collecting a new species of eriophyid on hibiscus at Hilo, Hawaii, February 9, 1945. Mr. H. H. Keifer believes it to be an undescribed species of *Epitrimerus,* and is preparing figures of this mite. This mite is particularly abundant during dry weather. High infestations are found on young leaves, petioles and stems of the growing point. The infested leaves generally curl outward and turn reddish yellow, especially at the tips. Old leaves also turn yellow before dropping off.

Mites on citrus—Mr. Look reported that the cosmopolitan citrus rust mite, *Phyllocoptruta oleivorus* (Ashmead) (det. H. H. Keifer), is one of the commonest mites on citrus plants at Hilo, Hawaii. A tarsonemid, probably the broad mite, *Hemitarsonemus latus* (Banks), is also destructive to seedlings and mature citrus trees. Papaya, potato, mango seedlings, dahlia, *Solanum nodiflorum* and *Bidens pilosa* are also commonly infested with tarsonemids.

First records of aphids on Hawaii—Mr. Look presented the following on aphids not previously reported from the island of Hawaii; the ten tabulated were identified by Prof. Essig.

Species	*Host*	*Locality*	*Date*
Aphis ferruginea-striata Essig	carrot	Hilo	Jan. 18, '45
Aphis citricidus (Kirkaldy)	pomelo	Hilo	Feb. 13, '45
Aphis helichrysi (Kaltenbach)	*Ageratum conyzoides*	Hilo	Feb. 9, '45
Aphis rumicis Linn.	*Phaius grandiflorus*	Hilo	Feb. 13, '45
Capitophorus braggii (Gillette)	African daisy	Hilo	Feb. 15, '45
Myzus circumflexus (Buckton)	hibiscus	Hilo	Feb. 9, '45
Myzus convolvuli (Kaltenbach)*	cucumber	Mountain View	Jan. 9, '45
Myzus convolvuli (Kaltenbach)*	rhubarb	Waimea	Jan. 19, '45
Myzus ornatus Laing*	rhubarb	Waimea	Jan. 19, '45
Rhopalosiphum nymphaeae (Linn.)	waterlily	Hilo	Feb. 14, '45
Rhopalosiphum pseudobrassicae (Davis)	mustard cabbage	Kamaili	Dec. 20, '44

* Single alate.

Also reported by Mr. Look, but not new records, were the palm aphid, *Cerataphis lataniae* (Boisduval), and the banana aphid, *Pentalonia nigronervosa* Coquerel. Also observed in the field were *Aphis maidis* Fitch and *Brachycolus heraclei* Takahashi. *Toxoptera aurantii* (Fonscolombe) previously recorded on coffee at Kona by Illingworth (Proc. Haw. Ent. Soc., **7**: 249, 1929) was also collected, breeding on *Macadamia,* hibiscus and *Vanda* orchid.

Tromatobia rufopectus (Cresson)—Dr. Swezey reported having found five egg "cocoons" of the spider *Argiope avara* Thorell in a tangle of web and dried leaves in a bush of *Duranta repens* in his garden, May 5, each of which contained cocoons of the ichneumonid predator *Tromatobia rufopectus,* with 8, 16, 18, 22 and 23 respectively per spider cocoon. From one spider cocoon the parasites had already issued; in another the parasites had died; in the other three cocoons the *Tromatobia* cocoons showed exit holes of the eulophid hyperparasite, *Pleurotropis wilderi* (Howard), and there were a few dead specimens of the latter. This was the first occurrence of these two parasites in his garden. The *Argiope* spider was not found, but one of its webs was observed a few months ago. In one spider egg cocoon were two pupae of the hyponomeutid moth, *Pyroderces rileyi* (Walsingham) from which moths issued later.

Omphisa anastomosalis (Guenée)—Dr. Swezey exhibited eggs of this pyralid moth, the sweet potato stem-borer, in a glass vial where they had been deposited by a female moth captured at light at his residence, May 12. Seventy eggs were laid, most of them attached to the surface of the glass, but a few free. They are very pale green, very shortly oval with a feeble reticulation on the surface, about half a millimeter in their shorter diameter, and slightly more than half a millimeter in their longer diameter. There is a sort of projection, or flange, on one side.

Achaea janata (Linn.)—Mr. Fullaway reported the capture of this recent immigrant on Kauai in May 1945, by Stephen Au. He exhibited a specimen of the encyrtid, *Habrolepis* sp., recently taken at the Territorial nursery, Honolulu, on lima bean. This is a rare insect, having been taken only twice before; nothing is known of its habits.

Aneurobracon, a synonym of *Mesocoelus*—Mr. Fullaway stated that his braconid species, *Aneurobracon samoanus* (Proc. Haw. Ent. Soc., **11**: 45, 1941), should be known as *Mesocoelus samoanus* (Fullaway). *Aneurobracon* Brues 1930 being, according to C. F. W. Muesebeck, a synonym of *Mesocoelus* Schulz 1911 (Jl. Washington Acad. Sci., **25**: 282, 1935).

JUNE 11, 1945

The 474th meeting was held at the H.S.P.A. Experiment Station on Monday, June 11, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Carter, Faxon, Jensen, Pemberton, Rosa, Sakimura, Swezey, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. Bernard Brookman, O. K. Courtney, R. D. Eichmann, R. B. Humphrey, J. Guy Lewis, E. M. Miller and J. J. Raynes.

Capt. W. W. Wirth was unanimously elected to active membership in the Society.

PAPER

Dr. Williams presented his paper entitled "Psychoda pseudalternata, n.sp. (Diptera, Psychodidae)".

NOTES AND EXHIBITIONS

Bactra truculenta Meyrick—Dr. Swezey reported a lot of the eggs of this nutgrass borer being 92 per cent parasitized by *Trichogramma minutum* Riley. A handful of fresh nutgrass leaves was collected from a cane field on the grounds of the H.S.P.A. Experiment Station, June 4. On examination, 13 of the moth eggs were found on the under surface of the leaves, in clusters of from 1 to 6. Twelve of them were parasitized by *Trichogramma;* this demonstrates why there is so little effect on nutgrass by the larvae of *B. truculenta.*

Amyna natalis (Walker)—Dr. Swezey exhibited specimens of an agrotid new to Hawaii, taken in a Navy light trap at Hickam Field, Oahu; a total of six specimens was taken on May 14, 19, 22, 23 and 26, 1945. The moth is known from India, Burma, Celebes, New Guinea, Australia, Fiji, Tonga and Samoa, but there is no information concerning its habits or importance. Hampson lists a few synonyms (Catalogue of the Lepidoptera Phalaenae in British Museum, **10**: 461, 1910).

Polydesma umbricola Boisduval — Mr. Van Zwaluwenburg recorded the presence on Oahu of another agrotid moth new to the Territory, the second such immigrant to be found here within the past three weeks. Specimens were exhibited. On June 4, 1945, F. D. Kennedy of the H.S.P.A. Experiment Station submitted for identification, caterpillars and pupae collected by R. E. Mulholland at his residence, 1120 Koko Head Ave., Kaimuki, Honolulu. These insects were identified by Dr. Swezey as *Polydesma umbricola.* The species is recorded from West and South Africa, Madagascar, India, Ceylon, the Andamans, Burma, Formosa and Guam. Dr. Wil-

liams collected hatched cocoons near Noumea, New Caledonia, which Dr. Swezey identified as this species from pupal characters and from a larval head cast.

On June 5 Messrs. Williams, Rosa and Van Zwaluwenburg visited the Kaimuki address and found nearly mature larvae of *Polydesma* abundant in debris at the base of monkeypod trees (*Samanea saman* [Jacq.] Merrill). A few partially-grown larvae were found in dry blossom heads among the flower clusters near the ends of the branches. In the laboratory the caterpillars fed upon monkeypod foliage. In Guam, Dr. Swezey found the species associated with *Pithecolobium dulce* (Roxb.) Benth., but so far it has not been found on this tree in Honolulu. Dr. Williams' New Caledonia specimens were found under bark of *Albizzia*. Pupation occurs under loose bark attached to the tree, and takes place within a tough cocoon of silk combined with more or less woody material. A few pupae were found under stones on the surface of the ground.

A brief survey showed *Polydesma* to be generally distributed on *Samanea* throughout Honolulu from Kaimuki to Moanalua. Later, on June 8, Dr. Swezey found the larvae at Waipio substation. Two adult moths (a male and a female) were taken on June 5 in the Experiment Station garage on Makiki Street. From the original Kaimuki material Dr. Swezey obtained puparia of *Eucelatoria armigera* (Coquillett); further evidence of tachinid parasitism of *Polydesma* was observed elsewhere about Honolulu.

Eurytoma, a new enemy of *Latrodectus*—Mr. Rosa reported that several egg cases of the spider *Latrodectus geometricus* Koch, collected by his daughter, Miss Mary Frances Rosa, May 11, 1945 on the H.S.P.A. Experiment Station grounds, yielded, a week later, adults of *Eurytoma* sp., an insect new to Hawaii. The *Eurytoma* larvae are predaceous on the spider eggs within the case. The species has been tentatively determined by Mr. Fullaway as *Eurytoma arachnovora* Hesse,[5] a South African species. The same parasite was later bred from *geometricus* eggs collected at the H.S.P.A. Experiment Station, Honolulu, May 18 by Mr. Pemberton, and at Maili Point, Oahu, May 23 by Mr. Van Zwaluwenburg. On May 31 Messrs. Rosa and Van Zwaluwenburg observed adult *Eurytoma* emerging from field-collected egg cases of *L. mactans* (Fabr.) at Lualualei, Oahu.

Anacamptodes fragilaria (Grossbeck)—Mr. Pemberton reported that the new immigrant geometrid, referred to earlier as *Stegania*, had now been determined by H. W. Capps of the U. S. National Museum, through Mr. Muesebeck, as *Anacamptodes fragilaria*. It is a native of southern California, but little is known there of its habits. It was described in the genus *Cleora* (Canad. Ent., **41**: 194, 1909) but was later removed to *Anacamptodes* by McDunnough

[5] Later, after examining Hawaiian material, Dr. A. J. Hesse wrote that it is not this species. [Ed.].

(Dept. Agr. Canada, Bul. Ent. **18**: 29, pl. v, fig. 10, 1920). Mr. Van Zwaluwenburg remarked that he recently found larvae of this species feeding on foliage of woodrose (*Ipomoea tuberosa*) at Maile, Oahu, under circumstances which precluded the possibility that they had dropped onto the vine from another food plant.

Achaea janata (Linn.)—Mr. Van Zwaluwenburg reported finding at Waianae, Oahu, larvae of this agrotid feeding on *Leucaena glauca, Acacia farnesiana* and on *Prosopis chilensis* ("kiawe"). The last-named was found earlier by Mr. Wirth to be a food plant of *Achaea*.

JULY 9, 1945

The 475th meeting was held at the H.S.P.A. Experiment Station on Monday, July 9, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Carter, Jensen, Marlowe, Nishida, Pemberton, Rosa, Sakimura, Swezey, Tanada, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. D. D. Bonnet, Bernard Brookman, E. D. Eichmann, E. J. Gerberg, Gilbert Gude, G. S. Starkey, G. S. Tulloch, J. P. Vinzant, J. E. Webb, Jr., and P. A. Woke.

NOTES AND EXHIBITIONS

A parasite of the onion moth—Mr. Tanada reported that on March 23 larvae of the plutellid onion moth (*Acrolepia assectella* [Zeller]) were collected on green onions in a vegetable garden at the University of Hawaii; later several more larvae were collected. From this material issued two adult moths and two braconid parasites, *Chelonus blackburni* Cameron. The specimens were identified with the aid of Dr. Swezey.

Megacerus alternatus Bridwell—Dr. Swezey reported for C. J. Davis that the latter had collected 21 specimens of this bruchid at Keauhou, Kona, Hawaii, May 24, 1945, on an *Ipomoea*. Undoubtedly this plant was the usual beach species, *I. pes-caprae*, as that is the usual host plant of this beetle. Apparently this is the first collection of this bruchid on the island of Hawaii, although F. C. Hadden reported seeing its work at Kailua, Hawaii, in November 1929. The round holes in old seed capsules is always evidence of infestation by this bruchid.

Omphisa anastomosalis (Guenée)—Dr. Swezey gave the following observations on the life history of the sweet potato vine-borer. A female caught at light produced 70 eggs overnight in a vial, May 12. Eggs hatched May 18 (6 days). The young caterpillars were placed among numerous sprouts on a sweet potato in a jar. They entered the sprouts at the axils, and after finishing the sprouts,

entered the tuber itself, where they completed their growth. Pupation took place in silken cocoons in burrows in the tuber. The first pupae were found June 14 (27 days); the first moth issued June 26 (12 days) and moths continued to issue until July 9. Hence the length of the stages was as follows: Egg stage 6 days; caterpillar stage 27-36 days; pupal stage 12-16 days; total, 45-58 days.

Ananca bicolor (Fairmaire)—Mr. Bianchi exhibited discolored leaves from a stool of sugar cane upon which a large swarm of this oedemerid beetle had been perched for about a month. The discoloration apparently was the effect of some toxic content of the beetles' excrement. Isolated particles of excrement were in all cases surrounded by small discolored areas, and when enough of such areas joined, the whole leaf became chlorotic. Five or six stools, each with many leaves so affected had been pointed out to Mr. Bianchi in a cane field at Waialua Plantation, Oahu.

Achaea janata (Linn.)—Mr. Bianchi recorded this agrotid from the island of Hawaii for the first time. It was found on June 5, 1945 at Pahala, and on June 7 near the entrance to Puu Waawaa ranch. Caterpillars were abundant in both places on castor bean plants along the Mamalahoa highway.

Baeus californicus Pierce—Mr. Bianchi reported the first recovery of this scelionid parasite of *Latrodectus* eggs on the island of Hawaii, where it was liberated in 1939. He found it at South Point on June 7, 1945. Of 18 egg cases of *Latrodectus mactans* (Fabr.) collected, one contained both male and female *Baeus*. Males had not been seen before in the Territory, although they have been described from California; they are winged, in contrast to the apterous females.

Latrodectus—Mr. Rosa reported an egg case characteristic of *Latrodectus geometricus* Koch, produced by a field-collected female spider from Lualualei, Oahu, having the coloration of a typical *L. mactans* (Fabr.). The progeny of this egg case showed a wide variation in color and markings.

Chaetogaedia monticola (Bigot)—Mr. Rosa reported rearing this tachinid fly from pupae of the agrotid *Polydesma umbricola* Boisduval, a new host record.

Heliothis attacking watermelon—Dr. Jensen reported a general attack by the corn earworm, *Heliothis armigera* (Hübner), on watermelons on the island of Molokai. The infestation was examined by Joseph Boyd, truck crop specialist of the University of Hawaii extension service, on June 30. Specimens of the larvae and of damaged melons were brought to Honolulu by Mr. Boyd. The larvae were found attacking melons in all stages of growth from newly set fruits to mature melons. The tissue along the walls of the feeding channels usually became dry and corky, and fermentation developed within the melons. Some of the infested melons were partially

edible, but most of them were considered a total loss. Of the 56 acres of melons growing on Molokai last month, approximately 75 per cent suffered damage from corn earworm, with an estimated loss of 50 per cent of the entire crop, according to Mr. Boyd.

Three fields, of over 10 acres each, comprised most of the watermelon acreage. The attack was general over these fields as well as in smaller plots. The heaviest infestations occurred in the homestead district, with lesser damage east of Kaunakakai. Although the literature records corn earworm larvae feeding on many host plants, no reference was found to extensive damage to watermelons by this insect. A few melon flies (*Dacus cucurbitae* Coquillett) were also reared from some of the melon samples brought from Molokai. However, the damage due to this insect was not considered severe during the past month.

Paraidemona mimica Scudder—Mr. Pemberton exhibited specimens of this grasshopper, found at Hickam Field, Oahu, on July 5, 1945, on grass and other low vegetation. The species was identified by Drs. Swezey and Williams. This is the first record of this acridid in Hawaii. It was described (Proc. U. S. Nat. Mus., **20** [1124]: 43-44, 1898) from material collected in Texas. The specimens collected at Hickam Field have been held in the laboratory for preliminary feeding tests, and have fed on grass, *Bidens pilosa,* and sparingly on sugar cane leaves, *Cyperus rotundus* and *Emilia flammea.* There are apparently no records of this species being of economic importance in Texas. However, it may well prove otherwise in Hawaii after it has become generally distributed.

Polydesma umbricola Boisduval—Dr. Williams spoke of finding this agrotid moth in its larval, pupal and adult stages on monkeypod trees, *Samanea saman,* at Kawela, Molokai, June 19, 1945. This is a new island record. From its larvae were reared the tachinid, *Eucelatoria armigera* (Coquillett) and from the pupae, the ichneumonid *Ephialtes hawaiiensis* (Cameron), while a young caterpillar yielded a *Hyposoter exiguae* (Viereck) (Ichneumonidae). A chalcid, *Brachymeria obscurata* (Walker), issued from a *Polydesma* pupa. *Polistes* wasps were busy searching cracks and openings in the bark. A specimen of the ostomid (trogositid) beetle, *Tenebroides nanus* (Melsheimer), was found in this *Polydesma* material.

Cryptorhynchus mangiferae (Fabr.)—Dr. Williams reported that at Mapulehu, Molokai, the mango weevil did a great deal of damage in the larval state to mango seeds intended for planting, while in two instances the adults were observed with the beak inserted in a large fruit, one of which hung on the tree. This damage by adults would have lessened the market value. These observations were also made previously by George Otsuka, caretaker of the H.S.P.A. installations at Mapulehu.

Metioche sp.—Dr. Williams mentioned catching with a sweep net one of these tiny gryllids in his garden on upper Keeaumoku Street, Honolulu, late in 1944. The specimen was not preserved. Then on June 4 and 6, 1945, macropterous individuals apparently of this *Metioche* (determined by E. C. Zimmerman) were taken at a light trap operated by the Navy at Hickam Field. From June 10 on, other brachypterous forms were again taken in his garden. The genus occurs in parts of Oceania; it is a new record for Hawaii.

Polemistus luzonensis Rohwer—Dr. Williams reported taking this tiny wasp (Sphecidae, Pemphredoninae) on the grounds of the H.S.P.A. Experiment Station, Honolulu, on June 30, 1945, and on several days following. The wasps, which are presumably aphid hunters, were all males, and were flying up and down two posts containing small nail holes, and supporting a portion of one of the greenhouses. Others were later seen in similar flight alongside the trunk of a royal palm on the Station grounds. Dr. Williams first found this wasp in the Philippines in 1917, and from that material Rohwer described the species (H.S.P.A. Expt. Sta., Bul. **14,** Ent. ser., pt. 1: 5-6, 1919). The wasp is new to Hawaii.

AUGUST 13, 1945

The 476th meeting was held at the H.S.P.A. Experiment Station, on Monday, August 13, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Carter, Faxon, Fullaway, Hadden, Holdaway, Jensen, Pemberton, Rosa, Sakimura, Swezey, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. A. L. Block, D. D. Bonnet, Bernard Brookman, J. R. Douglas, R. D. Eichmann, Gilbert Gude, E. M. Miller, R. Z. Pepper and J. E. Webb, Jr.

Dr. Swezey was unanimously elected to honorary membership in the Society. The President remarked that such action was most fitting, Dr. Swezey having witnessed the formation and growth of the Society, and having been one of its founders.

PAPERS

On behalf of C. J. Davis and A. L. Mitchell, Mr. Pemberton presented a paper entitled: "Notes on Host Records of Philaenus spumarius (Linn.) at Kilauea, Hawaii National Park (Homoptera, Cercopidae)". For Mr. C. F. W. Muesebeck, Mr. Fullaway presented a paper entitled: "A new Apanteles from Hawaii (Hymenoptera, Braconidae)". Mr. Fullaway also presented Howard L. McKenzie's paper: "A new Species of Lepidosaphes attacking Dendrobium Orchids in Hawaii and California (Homoptera, Coc-

coidea, Diaspididae)". For Lt. Sherwin F. Wood, Dr. Carter presented a paper entitled: "The Occurrence of Trypanosoma conorhini Donovan in the Reduviid Bug Triatoma rubrofasciata (Degeer) from Oahu, T. H.".

NOTES AND EXHIBITIONS

Systole geniculata Förster—Mr. Sakimura reported that this fennel seed chalcid, known from the Territory since 1930, was discovered causing damage to Chinese parsley, "yuen-sai" (*Coriandrum sativum*) in Manoa, Honolulu. This new host plant is a close relative of fennel and carrot. The larvae feed within the seeds, making them non-viable. Seeds from infested plants showed a very poor rate of germination. Identification of the insect was made by Dr. Swezey.

Pamakani stem gall fly—Mr. Fullaway reported that the trypetid fly, *Procecidochares* sp., which breeds in the stems of "pamakani" (*Eupatorium glandulosum*), is now established on Mt. Tantalus, Oahu, and in upper Kula on the island of Maui. The fly is an introduction from the Cuernavaca region of Mexico, by the Board of Agriculture. Since January, collections made by Mr. Krauss have been received frequently by air, and the adult flies either liberated or held for propagation. The fly is easily handled, and during the summer its numbers were increased many times by cage rearing. Fresh galls have been noticed on Tantalus for several months, but the establishment on Maui is very recent, for shipments to that island were not made until the middle of May.

Eurytoma sp.—Mr. Fullaway spoke of this new immigrant wasp, predaceous on eggs of *Latrodectus*. Specimens sent to the U. S. National Museum were reported by A. B. Gahan to be similar to a *Eurytoma* of similar habits from Puerto Rico, which may be identical with *E. arachnovora* Hesse* from South Africa.

Hercinothrips femoralis (Reuter)—Mr. Bianchi reported heavy damage to bananas by this thrips at the Campbell plantation at Mokuleia, Oahu. In some of the western fields thrips are so abundant that hardly a bunch of fruit escapes without some damage, and in many cases every individual fruit is completely discolored. The eastern end of the plantation is less badly affected but, according to the manager, damage is on the increase there. In some fields the injury by thrips is aggravated by the work of red spider, the effects of drought and the difficulties currently impeding proper cultivation. When the thrips population on a fruit is relatively small the injury is a characteristic "silvering". When the number of thrips is great, or perhaps when their work is aggravated by red spider and other factors, each banana assumes a peculiar reddish color, which, while not affecting the edibility of the fruit, mars its appearance and lowers its market value.

* See p. 476.

Anacamptodes on Molokai and Maui—Mr. Van Zwaluwenburg reported finding larvae of *A. fragilaria* (Grossbeck) on the south coast of Molokai on July 18, 1945; they were on kiawe (*Prosopis chilensis* [Molina] Stuntz) at various places along the main road from the Kamalo district, about eight miles east of Kaunakakai, to a point about five miles west of the town. Mr. Pemberton added that he had observed this moth at Haiku, Maui on July 26. These are new island records for the species, previously known only from Oahu and Kauai.

Polydesma umbricola Boisduval—Mr. Pemberton reported that Douglas J. Worcester and William Brandt had found this agrotid moth and its caterpillars abundant on monkeypod trees (*Samanea saman*) at Lahaina, Maui, early in July 1945.

Orchidophilus peregrinator Buchanan — Dr. Swezey exhibited specimens of this orchid weevil collected at a Nuuanu orchid garden in June. One hundred thirty-four specimens were given him by Dr. Carter, with the idea that there might be more than one species among them. However, upon comparison with a paratype specimen under a binocular microscope, all proved to be *O. peregrinator*. This indicates that this species is of more importance in Honolulu than Dr. Swezey realized when preparing his recent paper on "Insects Associated with Orchids" (Proc. Haw. Ent. Soc., **12**: 343-403, 1945).

Heliothis armigera (Hübner)—Dr. Swezey exhibited a moth of the corn earworm reared from a uniformly green caterpillar found by him on a leaf of tree tomato (*Cyphomandra betacea* Sendtner), where it had been feeding extensively. He had at first thought the caterpillar might be a different species, but the moth which issued proved to be the same as a specimen reared from an ear of corn whose caterpillar had the usual corn earworm markings.

Acrapex exanimis (Meyrick)—Dr. Swezey exhibited specimens of this agrotid moth found among material from a wind trap operated by Mr. Sakimura in a pineapple field in the Kunia district, Oahu, March 9, 1943. It is the first specimen he had seen since 1927 and 1928, when he reared several moths from larvae boring in the stems of a grass (*Panicum torridum*) growing on the western slope of Koko Head, Oahu. The moth was described by Meyrick as a *Caradrina* (Fauna Haw. **1**:153, 1899) from a single worn female collected in Kona, Hawaii by Dr. Perkins. It was redescribed by Meyrick from material reared by Dr. Swezey from Koko Head (Proc. Haw. Ent. Soc., **7**: 92, 1928), and an account of its life history was given by Dr. Swezey (l.c.,: 179-181, 1928). More recently two specimens were found among material from a light trap operated in the Kunia district by Major J. E. Webb, Jr., of the 18th Medical General Laboratory. These moths must have flown down from the forest where *Panicum kaalense* grows, for Dr. Swezey

had found this grass with stems bored, along the trail near the base of Mt. Kaala, but had failed to find any larvae in the stems at the time.

Weevil damage to Vanda orchids—Dr. Holdaway reported that the orchid weevil, *Orchidophilus peregrinator* Buchanan, probably a native of the Philippines, has been causing serious injury in a large commercial orchid garden in Nuuanu Valley, and materially reducing the production of *Vanda* blooms. Injury results principally from the feeding of the adults on the buds, and the feeding of the larvae in the leaves and aerial roots. Since September 1944 studies on the control of the weevil have been undertaken in cooperation with William Kirch of the University Experiment Station orchid project and Robert Warne of Nuuanu. These studies, involving eight different chemicals, have extended from greenhouse experiments to studies on field control involving weevil counts and flower production in the orchid garden. The experiments, which have indicated the superiority of DDT over all other insecticides, will be presented in detail at a later date.

Other observations have indicated that this weevil is capable of serious injury also to *Phalaenopsis* and *Dendrobium* orchids. Dr. Swezey (Proc. Haw. Ent. Soc., 12: 346-348, 1945) records that the species has been intercepted at Honolulu on the following orchids from the Philippines: *Phalaenopsis schilleriana, P. amabilis* and *Grammatophyllum multiflorum*. He also states that the only record of its occurrence in Honolulu was in 1928 in the orchid house of the late Mr. F. C. Atherton, the first record of the weevil in Hawaii. Since the preparation of Dr. Swezey's paper, Dr. Carter (Proc. Haw. Ent. Soc., 12: 223, 1945) has recorded the weevil in *Vanda teres*. It is apparent from our observations during the past twelve months that this weevil has become entrenched in orchids on Oahu, and is capable of serious injury to the growing orchid industry.

SEPTEMBER 10, 1945

The 477th meeting was held at the H.S.P.A. Experiment Station on Monday, September 10, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Faxon, Holdaway, Jensen, Keck, Pemberton, Rosa, Sakimura, Swezey, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. J. E. Alicata, E. W. Bushing, D. D. Bonnet, Bernard Brookman, R. D. Eichmann, E. M. Miller, J. J. Raynes and P. W. Weber.

Dr. Holdaway proposed Dr. J. E. Alicata for membership in the Society.

PAPERS

Dr. Swezey presented two papers, one: "Some New Species of Cerambycidae from the Island of Hawaii (Coleoptera)", the other by himself and Mr. Zimmerman: "Synonymic Notes on Argyroploce illepida (Butler) and A. carpophaga (Walsingham) (Lepidoptera, Eucosmidae)". Dr. Williams presented a paper entitled: "Stigmatomma (Fulakora) zwaluwenburgi, a new Species of Ponerine Ant from Hawaii".

NOTES AND EXHIBITIONS

Additional host plants of *Polydesma*—On August 20, Messrs. Rosa and Van Zwaluwenburg found larvae and pupae of *P. umbricola* Boisduval under bark of *Albizzia lebbek* (Linn.) Bentham. Evidence of feeding was abundant on the tender leaves. The next day numerous *Polydesma* larvae, large and small, were found in debris and under stones at the base of isolated *Pithecolobium dulce* (Roxb.) Bentham ("opiuma") trees, which had suffered considerable foliage damage. One *Erebus odora* (Linn.) was also found associated with opiuma. Dr. Williams found *Polydesma* on *Albizzia* in New Caledonia, and Dr. Swezey found it associated with *P. dulce* on Guam, but until now neither plant was known to be a host for this agrotid in Hawaii.

Corn earworm infesting watermelon—Dr. Holdaway commented on a recent record by Dr. Jensen of attack by corn earworm (*Heliothis armigera* [Hübner]) on watermelons on Molokai. This is apparently the first record of this species attacking watermelon. Speculation on the reasons for this infestation is of interest. During 1944 there was considerable wartime planting of corn on Molokai: 1,200 to 1,500 acres. During 1945 the acreage was somewhat less. By June 1945, when the infestation of watermelons was recorded, there was very little corn on the island. Kaunakakai, where the infestation occurred, is not in the direct line of the prevailing wind from the Kualapuu region where the large plantings of corn were. However, it seems quite probable that a large population of earworm moths developed in the corn were available for oviposition in the absence of the more favored host, corn. Some years ago a somewhat similar state of affairs was encountered when lettuce, not a normal host, was attacked by *Heliothis* larvae at Waimea, Hawaii. As a result, the moths oviposited on lettuce. The larvae caused injury to the lettuce, but could not be reared through to adults on that plant.

A heavy infestation of corn aphid—Dr. Holdaway reported heavy infestations of corn aphid, *Aphis maidis* Fitch, observed during the past two weeks on sweet corn at the Army farm, Kipapa airfield, Oahu. The infestation was so heavy that in two fields with corn

plants 3 to 4 feet and 5 to 6 feet high respectively, almost every plant is infested, many of them severely. In the older planting infestation must run to many thousands of aphids per plant; leaves are covered with a thick encrustation of aphids; leaves of badly infested plants are wilted, and some show a dry, chlorotic condition. It is reported that two years ago at about this time of year, heavy infestations also occurred. At that time a cessation of corn growing was followed by reduction of the trouble. These infestations are interesting from various angles. USDA-34 is apparently a variety very susceptible to corn aphid. Moreover, corn has now been grown continuously at Kipapa for several years, and thus there has been a continuous supply of susceptible food for building up a high population. It seems as though these two facts with a possible third—particularly favorable weather conditions for increase of the aphid—are responsible for the present infestation.

Rhipidius sp. in Hawaii—Dr. Williams exhibited several male specimens of this curious rhipiphorid beetle, new to Hawaii, which is probably parasitic in the cockroach, *Blattella germanica* (Linn.). Such a beetle was first observed as an interception on an Army plane from the South Pacific on January 25, 1944, when it was dissected out of an adult *B. germanica.* Later it was taken at light traps at Hickam Field and at Ewa, Oahu, by Mr. Wirth, who submitted the catch to Dr. Williams. The beetles are now in the H.S.P.A. Experiment Station collection with their dates of capture from late June to late August 1945. Hypermetamorphosis occurs in *Rhipidius* much as it does in the Meloidae. The male *Rhipidius* has flabellate antennae and short elytra; the female is apterous and larviform and remains within the body of its host. *Rhipidius pectinicornis* Thunberg (*R. blattarum* [Sundevall]) is European and has been introduced into the United States. Our species has not yet been determined.

OCTOBER 8, 1945

The 478th meeting was held at the H.S.P.A. Experiment Station on Monday, October 8, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Carter, Faxon, Fullaway, Jensen, Nishida, Rosa, Swezey, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. Bernard Brookman, E. J. Gerberg and G. S. Starkey.

Dr. J. E. Alicata was unanimously elected to active membership in the Society. Mr. Clifton J. Davis was nominated for corresponding membership.

It was unanimously voted to send $50 to the Zoological Society of London, for the Zoological Record fund.

PAPER

On behalf of Dr. R. I. Sailer, Mr. Zimmerman presented a paper entitled: "The Synonymy and Distribution of Trichocorixa reticulata (Guérin-Méneville) (Hemiptera, Corixidae)".

Apanteles tapatapaoanus Fullaway—Mr. Fullaway proposed the above new name for the braconid parasite of a sweet potato *Bedellia* from Samoa, described by him as *Apanteles bedelliae* (Proc. Haw. Ent. Soc., **11**: 46, 1941) from material bred by Dr. Swezey. In naming this species the fact was overlooked that the name *bedelliae* had previously been used by Viereck (Proc. U. S. Nat. Mus., **40**: 174, 1911) in describing an *Apanteles* bred from *Bedellia* at Washington, D.C. It was suggested to Mr. Fullaway by Mr. Pemberton that the two *Apanteles* might be identical, but after examination of many examples of the American species Mr. Fullaway states definitely that the Samoan species is different. Hence a new name is necessary, and *Apanteles bedelliae* Fullaway becomes *A. tapatapaoanus* Fullaway. *A. bedelliae* Viereck, introduced from Kansas during the past summer by the Board of Agriculture, is now established in a few localities on Oahu.

Two aleyrodids new to Hawaii—Mr. Zimmerman reported that Miss Louise Russell, of the U. S. Bureau of Entomology, has identified for him two aleyrodids not hitherto reported from the Territory. One is the iris whitefly, *Aleyrodes spiraeoides* Quaintance, from iris at Waiakoa, Kula, Maui, collected in April 1945. The other is *Aleyrodes shizuokensis* Kuwana, known to Dr. Swezey on *Oxalis* in his garden in Manoa Valley for the past 20 years. The iris-infesting species was described (U. S. Bur. Ent. Bul., Tech. ser., **8**: 36, 1900) from California; Kuwana's species was described from Japan (Pomona Coll. Jl. Ent., **3**: 620, 1911).

Corn aphid infestation—Dr. Holdaway and Mr. Nishida discussed further the infestation of *Aphis maidis* Fitch at Kipapa, Oahu, reported at the previous meeting. According to the field staff, aphid infestations had been heavy on repeated plantings of corn throughout the summer (since May or June). A parasite, apparently the braconid *Lysiphlebus testaceipes* (Cresson), present in the field when the earlier observations were made (during the first week of September), increased somewhat in abundance during September. Up to the last week of the month, however, it had not increased sufficiently to prevent heavy infestation of new corn plantings, so insecticidal control of the aphids was resorted to. Three applications of nicotine held the infestation down during the early growth of the crop, but, by the time the corn was 4 to 5 feet high and difficult to spray, heavy infestations had developed.

It was observed that aphids occurring in the "cone" of unfolded young leaves were not parasitized. During the last week in September heavy rains reduced aphid abundance considerably, while living aphids were removed from the leaves by the action of the rain, parasitized individuals remained. It is interesting to speculate on the possible result of the rainfall on the ultimate aphid population. The rains no doubt destroyed many adult parasites as well as aphids, but the parasitized aphids, protected from the mechanical action of the rain, may serve as a source of parasites to reduce the infestation more quickly than would have been possible without the aid of rain.

Capitophorus chrysanthemi Theobald—Dr. Jensen reported the occurrence in Hawaii of the above aphid, new to the Territory. Identification was by Prof. E. O. Essig after comparison with type material from the British Museum. Theobald described the species (Bul. Ent. Res., 11: 69, 1920) from material collected on chrysanthemum in South Africa; it occurs also in Egypt. Prof. Essig writes: "It is apparently of Chinese or Japanese origin. What I feel certain is the same species was described as *C. formosanus* by Takahashi from *Chrysanthemum sinensis* from Formosa in 1929." The record for Hawaii is based upon a single alate specimen collected by Dr. Jensen on chrysanthemum at Waipahu, Oahu, May 15, 1945. Although this host plant has been examined several times at Waipahu and elsewhere on Oahu, additional specimens of this aphid have not been found to date. The specimen from Waipahu was pale green in color and, in gross appearance resembled the potato aphid, *Macrosiphum solanifolii* (Ashmead), except that *C. chrysanthemi* is somewhat smaller and has darker, more conspicuous wing veins.

Neoclytarlus dodonaeae Swezey — Dr. Swezey said that four specimens of this cerambycid beetle had issued from a portion of *Dodonaea* trunk since the previous meeting of the Society, at which he presented a description of the species based on two specimens received earlier from C. J. Davis of the Hawaii National Park.

NOVEMBER 19, 1945

The 479th meeting was held at the H.S.P.A. Experiment Station on Monday, November 12, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Bianchi, Carter, Fullaway, Holdaway, Jensen, Nishida, Rosa, Sakimura, Swezey, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Messrs. G. F. Augustson, J. V. Benschoter, D. D. Bonnet, R. D. Eichmann, M. B. Folb, Gilbert Gude, M. S. Johnson, E. C. Nelson, R. Z. Pepper and P. W. Weber.

Mr. Clifton J. Davis was unanimously elected to corresponding membership in the Society. The name of Dr. David D. Bonnet was nominated for active membership.

PAPERS

Mr. Bianchi presented two papers: "Conocephalothrips tricolor, a new Urothripid from Hawaii", and "Additions to the Thysanoptera from the Island of Hawaii". Mr. Zimmerman presented two papers: "New Usingerius from the Philippines and Borneo (Coleoptera, Curculionidae)", and "Browne 1887, not Douglas 1888, the Author of Orthezia insignis (Homoptera, Coccoidea)", and, on behalf of Dr. Karl Jordan another, entitled: "On the Species of Araecerus Schoenherr known from the Hawaiian Islands (Coleoptera, Anthribidae)". Dr. Jensen presented a paper entitled: "The Identity and Host Plants of Blossom Midge in Hawaii (Diptera, Cecidomyiidae, Contarinia)".

NOTES AND EXHIBITIONS

Coloradoa rufomaculata (Wilson) — Dr. Jensen reported the presence in Hawaii of an aphid genus not previously recorded from the Territory. The aphid, *Coloradoa rufomaculata*, (*Aphis rufomaculata* Wilson. Ent. News, **19**: 261, 1908), was identified by Prof. E. O. Essig from material collected on chrysanthemum by Dr. Jensen at Waipahu, Oahu, May 15, 1945. It occurred in large numbers on the terminal growth of the plants, and to a lesser extent on the under surface of the older leaves. Apterae were abundant, but winged forms were very scarce. However, several alates were reared in the laboratory. In life this aphid appears bright green in general color, but has an inconspicuous whitish bloom due to the numerous small, capitate hairs on the body.

The species has been recorded from *Artemisia vulgaris* var. *indica, Chrysanthemum sinensis* and *Siegesbeckia orientalis* in Japan, and from chrysanthemum in India, Egypt, China, Australia, England, New York, Pennsylvania, South Carolina, Colorado and California.

A new eriophyid on mango—On behalf of Mr. Look, Dr. Williams presented the following note: An eriophyid collected from mango leaves at Hilo, Hawaii, April 1, 1945, has been identified by H. H. Keifer as an undescribed species of *Oxypleurites*. Heavy infestations on a mature tree and on seedlings were observed by Mr. Look during periods of dry weather at Hilo.

Graptostethus servus (Fabr.)—Mr. Van Zwaluwenburg said that a specimen of this lygaeid bug, collected some days earlier at Olowalu, Maui, was received on October 11 from D. J. Worcester. This is a new island record for the species, previously known locally only from Oahu and Kauai.

Achaea janata (Linn.)—Mr. Van Zwaluwenburg said that on October 12, R. E. Doty found a nearly full-grown larva of this immigrant agrotid feeding on *Euphorbia hirta* Linn. in Honolulu. This is the first record in Hawaii of this insect feeding on this host. Mr. Bianchi spoke of finding *Achaea* larvae feeding on *Codiaeum*, the ornamental croton, at Waialae, Honolulu. This is a new host record.

Metioche sp.—Mr. Rosa reported that he recently found this tiny cricket at Waianae, Oahu, as well as in his garden in Nuuanu Valley, Honolulu.

Eurytoma sp. on Maui—Dr. Carter reported that he had bred this recent immigrant which preys on eggs of *Latrodectus* spp., on the island of Maui, a new distribution record. The spiders are a pest of pineapples according to Dr. Carter, binding the growing, central leaves and causing abnormal growth.

Ceroplastes rubens Maskell—Dr. Carter reported finding this wax scale on a *Stanhopea* orchid plant in Honolulu.

Encyrtid parasites of *Pseudococcus brevipes* (Cockerell)—Dr. Carter said that *Anagyrus coccidivorus* Dozier and *Hambletonia pseudococcina* Compere, introduced from Central America and Brazil, were apparently doing good work on the pineapple mealybug in one locality in a Baldwin Packers field in west Maui, where the dominant ant was *Paratrechina longicornis* (Latreille), the so-called crazy ant. The parasitism was high, and pineapple wilt quite scarce.

New insect records from Kauai—Mr. Fullaway reported that Stephen Au, plant inspector on the island of Kauai, had recently submitted specimens from Koloa, Kauai, of the small cricket, *Metioche* sp., and of the new immigrant agrotid moth, *Polydesma umbricola* Boisduval. In an egg sac of the spider *Latrodectus geometricus* Koch, also from Kauai, *Eurytoma* sp. were present. This newly established predator on *Latrodectus* eggs was first found on Oahu in May, 1945.

DECEMBER 10, 1945

The 480th meeting was held at the H.S.P.A. Experiment Station on Monday, December 10, at 2:00 p.m., with President Jensen in the chair.

Members present: Messrs. Alicata, Bianchi, Bonnet, Bryan, Carter, Faxon, Fullaway, Holdaway, Jensen, McBride, Pemberton, Rosa, Sakimura, Swezey, Tanada, Van Zwaluwenburg, Williams, Wirth and Zimmerman.

Visitors: Miss Mabel T. Chong, Messrs. R. D. Eichmann, M. B. Folb, M. S. Johnson, L. K. Jones, J. G. Lewis and H. F. Riley.

Dr. David D. Bonnet was unanimously elected to active membership. Mr. J. Guy Lewis was nominated for membership in the Society.

This being the annual meeting, the following slate of officers to serve during the coming year was presented:

President	N. L. H. Krauss
Vice-President	Kay Sakimura
Secretary-Treasurer	F. X. Williams
Additional Members of Executive Committee	D. D. Jensen C. E. Pemberton

There were no further nominations, and the above nominees were elected to office.

The revised Constitution of the Society, together with the amendments proposed at the preceding meeting, was unanimously adopted.

President Jensen relinquished the chair to Mr. Sakimura, the vice-president elect, and presented the annual presidential address: "Virus Diseases of Plants and their Insect Vectors, with special Reference to Hawaii".

PAPERS

Dr. Williams presented a paper: "Two new Species of Astatinae, with Notes on the Habits of the Group (Hymenoptera, Sphecidae)". Mr. Zimmerman presented his paper: "A remarkable new Pseudopsectra from Maui (Neuroptera, Hemerobiidae)", and for Dr. Usinger the latter's: "Notes and Descriptions of Ceratocombus (Hemiptera, Cryptostemmatidae)". Dr. Swezey presented a paper entitled: "New Species of Hawaiian Lepidoptera".

NOTES AND EXHIBITIONS

Strumigenys (*Cephaloxys*) *membranifera* Emery var. *williamsi* Wheeler—Dr. Williams recorded the finding of a single specimen, a worker of this hypogaeic myrmicine ant, in soil at the H.S.P.A. Experiment Station in October, 1945, a new record for the island of Oahu. The variety was described from specimens collected under moss near Olaa, Hawaii in April, 1932. (Proc. Haw. Ent. Soc., 8: 276, 1933.)

Tenodera angustipennis Saussure—Mr. Bianchi exhibited an egg case of this mantid which had yielded the callimomid parasite *Podagrion mantis* Ashmead, as well as a single specimen of the eupelmid *Cerambycobius cushmani* Crawford.

Parasites of *Procecidochares* sp.—Mr. Fullaway exhibited a jar of the pamakani gall-fly (*Procecidochares* sp.) with inclusions of *Diachasma tryoni* (Cameron) and *Eurytoma* sp. It is suspected that both these parasites developed on the trypetid gall-fly.

A new geometrid moth—Dr. Williams reported that a single specimen of a geometrid moth, unlike any previously known here, according to Dr. Swezey, was caught in a light trap at Kaneohe, Oahu, by Mr. Wirth on August 23, 1945. The moth is brown with darker wavy bands across the fore and hind wings.

Notes on Hawaiian Tendipedidae (*Chironomidae*)—Mr. Wirth presented the following notes:

Tabulation of known Hawaiian species

	Named	Discussed by Williams (1944)* but unnamed	New
Tendipes (*Chironomus*)	1	1	1
Tanytarsus	1	..	2
Spaniotoma	1	3	..
Metriocnemus	..	2	..
Telmatogeton	3	2	..
Clunio	..	3	..
Total	6	11	3

Tendipes sp. A plain-winged *Tendipes* which may, on further examination, prove to be the same as specimens identified by Van Zwaluwenburg in late 1944 from a light trap at Hickam Field, has been taken in a light trap operated at Ewa, Oahu, in November, 1945. The Ewa specimens differ from *T. hawaiiensis* (Grimshaw) in lacking the pre-apical femoral dark bandings, the medial cross-vein is not infuscated, and details of the male genitalia are different. Typically the Ewa specimens are smaller than *hawaiiensis,* the brown markings are restricted, and the male antennae are more sparsely plumose.

Tendipes sp. A spotted-winged *Tendipes* from the Ewa light trap appears to be new to Hawaii. The first specimens were noted on October 25, 1945, and between that date and November 30, 65 females were taken in 27 trap-night's collections. Since only females have been taken, it is suggested that this species may be reproducing parthenogenetically. Dr. Williams collected a similar species in New Caledonia in 1940, including males.

Tanytarsus sp. Mt. Kaala, Oahu, November 6, 1945, W. W. Wirth. Nine males swept while swarming beside trail. A relatively large, black species with broad creamy bands on the tarsi. (*Tanytarsus lacteiclavus* Grimshaw is a small green species). New record for Hawaii, probably endemic.

Tanytarsus sp. Mt. Kaala, Oahu, November 6, 1945, W. W. Wirth. Two males swept while swarming beside trail. Black, smaller than the preceding species, with narrower bands (annulations). A new record from Hawaii, probably endemic.

Metriocnemus sp. Numerous specimens of what is probably the same as Williams' *Metriocnemus* no. 2 (l.c.: 165, 1944) were taken on Mt. Kaala, Oahu, by sweeping on August 22 and November 6, 1945.

Clunio sp. Edwards identified specimens sent him by Williams as three different new species of *Clunio* (l.c.: 170-171, 1944), each from a different locality on the Oahu coast. Numerous males, of which three had the wingless female attached in copulation, were taken December 1-5, 1945 in a light trap operated at Lanikai, Oahu.

* Proc. Haw. Ent. Soc., 12, 154-171, 1944.

One male with attached female was taken in light trap operated at the Kaneohe Territorial hospital, about one mile inland.

Clunio sp. One male was taken in a light trap operated in Hilo, Hawaii at the Plague Laboratory in November, 1945. A different species from the Lanikai specimens. The first record of *Clunio* from the island of Hawaii.

Notes on Hawaiian Heleidae (Ceratopogonidae)—Mr. Wirth presented the following:

The four known species of Hawaiian heleids have been collected as follows:

1. *Apelma brevis* Johannsen. In light traps at Wheeler Field, Oahu, November, 1945; Schofield Barracks, Oahu, November, 1945; Lanai City, Lanai, October 10, 1945 (D. D. Bonnet). The last record is apparently the first from Lanai, though the species should have been present for a long time in the large pineapple plantings there.

2. *Forcipomyia ingrami* Carter. Commonly collected in light traps and by hand collections throughout Oahu, from the summit of Mt. Kaala (4,030 ft.) to sea level. What may be a different form has been taken in a light trap at Wheeler Field in November, 1945, as well as by hand collections from Manoa Valley, Kamananui stream and Mt. Kaala, all on Oahu. Females are much smaller and darker than typical *ingrami*, and the hairs of the mesonotum are black rather than golden. *F. ingrami* was also taken in the light trap at Hilo, Hawaii, in November, 1945.

3. *Dasyhelea calvescens* Macfie. Adults were abundant at Hanauma Bay, Oahu, the type locality, swarming over the rocks back of the shore. Larvae were taken from the felt-like growth of algae and diatoms in the shallow pools in the rocks receiving the splash from the sea at high tide.

4. *Dasyhelea hawaiiensis* Macfie. Commonly collected in light traps and by hand collections throughout Oahu, from Mt. Kaala to sea level. The Mt. Kaala specimens were entirely black, even to the tips of the halteres. Specimens taken in a light trap on Judd Street, Honolulu, were a brilliant yellowish green with small brown thoracic markings and with a black dorsal patch on the abdomen. Macfie (Stylops, 3: 133-134, 1934) described the species from Hering Valley specimens which he characterized as brownish, with the scutellum and halteres paler. Either this species is exceedingly variable, or characters may be found which will definitely separate what is probably a highland, from the lowland, form. A series of adults collected at one of the falls in upper Manoa Valley exhibits a wide range in color variation, from yellow to dark brown. The extreme color forms also differ markedly in the distribution of macrotrichia on the wings. *D. hawaiiensis* was also taken in the light trap in Hilo, Hawaii, on November, 1945; this is apparently a new island record for the species.

One male with attached female was taken in light trap operated at the Kaneohe Territorial hospital, about one mile inland.

Clunio sp. One male was taken in a light trap operated in Hilo, Hawaii at the Plague Laboratory in November, 1945. A different species from the Lanikai specimens. The first record of *Clunio* from the island of Hawaii.

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LEHR ARTIMAN WHITNEY
1890-1945

The death of the veteran entomologist and plant quarantine inspector, Lehr Artiman Whitney, occurred February 21, 1945, after a lingering illness. At his death Mr. Whitney was 54 years of age. During the past quarter century his residence had been in Honolulu.

LEHR ARTIMAN WHITNEY

Mr. Whitney was born September 25, 1890, in Nevada, Iowa, but most of his early life was spent in California, where he attended school in the town of Orange. As a young man he worked in the orange groves of southern California, and it was there undoubtedly that he became interested in the pest problems of the horticulturist, an interest which eventually led to his adoption of the career of agricultural inspector. From 1911 on, he was contributing notes on insect pests to the monthly bulletin of the California State Commissioners of Horticulture. In 1920, while working with his brother, B. B. Whitney, in the San Francisco office of the state quarantine service, he was engaged by the Hawaiian Board of Agriculture and Forestry to take the place vacated by D. B. Langford,

as assistant to the late E. M. Ehrhorn. On the retirement of Mr. Ehrhorn in 1926, Mr. Whitney became the active head of the plant quarantine service and made a record there for quiet, efficient handling of the plant quarantine work.

Despite heavy physical handicaps, Mr. Whitney achieved distinction as a coccidologist, and his collection and study of coccids made him a valuable worker in the entomological field here, where these insects had long been neglected. Together with his wife Bernice, he spent much time also on the Diptera. In 1937 Mrs. Whitney died, and the loss of his wife was a blow from which Mr. Whitney never recovered. He became severely ill in 1939, and although he lived on beyond the expectation of everyone, his professional life was ended.

Mr. Whitney was a prominent Mason, and the Masonic memorial service conducted over his ashes was attended by the members of a committee from the Hawaiian Entomological Society. Mr. Whitney is survived by two brothers in California, one of whom, Mr. Blenn B. Whitney, has already been mentioned. The other is Mr. Mervin M. Whitney of Long Beach, California.

D. T. Fullaway

F. X. Williams

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D. T. Fullaway

F. X. Williams

THE APHIDIINAE OF NORTH AMERICA*

(A Review)

By D. T. FULLAWAY

This is an excellent treatise on an important group of insects not reviewed in America for a third of a century. Dr. Smith's work is thorough and painstaking, and adds considerably to our knowledge of these primary parasites of the aphids. Three new subgenera and twenty-six new species are made as a result of the revision, and six names are newly synonymized. There is a chapter on methods of study, general biology of the Aphidiinae, and the author's view on the important taxonomic characters; also a host index of species studied by the author, and a bibliography. The illustrations are of the author's own making and should be useful in the discrimination of the species. The three species known in Hawaii are included in the treatment, but the reviewer has not yet tested the accuracy of their determination by the method Dr. Smith uses for species discrimination.

* By Dr. Clyde F. Smith (Contributions in Zoology and Entomology, 5, Ohio State University, vii + 154 pp., 17 pls., 1944.)

Proc. Haw. Ent. Soc., Vol. XII, No. 3, May, 1946.

REVISED CONSTITUTION

(Adopted at the meeting of December 10, 1945)

ARTICLE 1. *Name.*

The name of this organization shall be the Hawaiian Entomological Society.

ARTICLE 2. *Objects.*

The objects of the Society shall be to promote the study of entomology, and to encourage friendly relations between those interested in the science.

ARTICLE 3. *Members.*

The Society shall consist of Active, Junior, Corresponding and Honorary members. No corresponding member shall be elected from residents on the island of Oahu. Junior membership shall be limited to those under eighteen.

Election shall be by ballot, nomination having been made by a member of the Society at a previous meeting. A majority vote of Active members present shall be necessary for election.

The annual dues for Active members shall be five dollars, for Junior members two dollars and fifty cents, and for Corresponding members two dollars, unless election takes place after the last day of September, when no fees shall be collected for that year. Active members who move away permanently shall become Corresponding members on the January first following their departure. Honorary members, and ladies who are Active members, shall be exempt from dues.

Any member in arrears for one year may, after due notification, be dropped from the rolls. No member in arrears shall be entitled to a vote or to the Proceedings of the Society for that year.

ARTICLE 4. *Officers.*

The officers of the Society shall be a President, a Vice-President and a Secretary-Treasurer to be elected by ballot at the annual meeting. These officers, together with two Active members to be elected by the Society in the same manner as the officers, to form an Executive committee. The Executive committee shall constitute a nominating committee for said officers of the Society, and shall present a slate of officers to the Society. Nominations may also be made from the floor.

ARTICLE 5. *Duties of Officers.*

(a) The duty of the President shall be to preside at the meetings of the Society and committees, and regulate all the discussions and proceedings therein, and to execute or see to the execution of the By-Laws. In case of an equality of vote, the President shall have a double or casting vote. It shall be the duty of the President to deliver an address at the closing meeting of the year.

(b) In the absence of the President the Vice-President shall fill his place, and shall for the time being have all the authority, power and privilege of President.

(c) In the absence of the President and Vice-President a chairman protem shall be elected by a majority vote of Active members present.

(d) The Secretary-Treasurer shall conduct all the correspondence of the Society, keep a list of members, give due notice of all meetings and take and preserve correct minutes of the Proceedings of the Society; shall have charge of all monies of the Society, collect all dues, assessments, receipts and contributions, make disbursements under direction of the Executive committee, and submit a report of the state of finances of the Society at the annual meeting or whenever called for.

(e) The Executive committee shall appoint one or more Active members from among themselves or otherwise, as Librarian, Curator and Editor, respectively, and two additional members to constitute with the Editor an editorial committee. The Editor's duties shall be to edit the publication of the Society and arrange for their publication. The Librarian and Curator shall have custody of the library and collections respectively and shall manage them under the direction of the Executive committee.

ARTICLE 6. *Meetings.*

The regular meetings shall be held, unless otherwise ordered by the Executive committee, on the second Monday of each month. The annual meeting for the election of officers shall be the regular meeting for the month of December. Special meetings may be called by the Executive committee or by the President at the written request of five Active members. Five members shall constitute a quorum for the transaction of business.

ARTICLE 7. *Amendment.*

The Constitution may be amended at any regular meeting by a two-thirds vote of Active members present, a copy of each amendment proposed having been presented at the preceding regular meeting.

ARTICLE 8. *Order of Business.*

(a) Reading and approval of minutes.
(b) Reports of officers and committees.
(c) Nomination and election of members.
(d) Nomination and election of officers at annual meeting.
(e) Unfinished and new business.
(f) Presidential address at annual meeting.
(g) Presentation of papers.
(h) Presentation of notes and exhibitions.
(i) Motion to adjourn.

Earlier references to the Constitution of the Society are to be found in the Proceedings as follows:

1: 5-8, 1905.
1: 60, 1906.
2: 42-44, 1909.
4: 249, 257-260, 1919.
7: 388-389, 1931.
8: 221, 1933.
10: 16, 18, 1938.

Conocephalothrips tricolor, a New Urothripid from Hawaii

By FRED A. BIANCHI
Experiment Station, H.S.P.A.

(Presented at the meeting of November 19, 1945)

The superfamily Urothripoidea consists of the single family Urothripidae, comprising seven genera and about 25 species. Of these only the Australian *Octurothrips pulcher* Priesner (Konowia, **10**: 10, 1931) and the American *Stephanothrips occidentalis* Hood and Williams (recorded in Proc. Haw. Ent. Soc., **8**: 503, 1934) have been found in the Pacific region. It is of interest, therefore, to add to the family a well differentiated eighth genus, the circumstances of whose discovery indicate, if not necessarily its endemicity in Hawaii, at least the probability of its ancient establishment in these islands. The two specimens upon which the new species and genus are based were found at an elevation of some 4,000 feet on the small, swampy and almost continuously rainy plateau which crowns steeply-sloped Mount Kaala and which, until the construction of a cable trolley some four years ago, was the most thoroughly isolated area of its size on the island of Oahu.

Distinguished at once from the rest of the family by the greatly protracted vertex of the head, the new genus is apparently most nearly related to Bagnall's *Urothrips* (Ann. Mus. Nat. Hung., **7**: 126, 1909). It is like *Urothrips* in the shape and number of antennal segments, in the lack of tarsal armature of any kind, and in the absence of prominent bristles on the vertex of the head. It is unlike *Urothrips,* on the other hand, in the possession of white subhypodermal pigment, in the lack of heavy reticulation, in having four instead of six major terminal hairs, and in having both the maxillary and the labial palpi unmistakably two-segmented. The description follows:

Conocephalothrips gen. nov.

Antennae inserted ventrally, seven segmented; segment 3 with narrow pedicel; segments 3, 4, 5 broadly joined; segments 4, 5 about as broad as long; segments 6, 7 narrower than long, broadly pedicellate. Vertex conical, produced far forward of eyes and antennal bases, without prominent bristles. Tarsi without claws or spurs. Tube about six times as long as wide and considerably longer than abdominal segment 9; tip of tube with four long hairs separated by minor ones. The genotype is:

Conocephalothrips tricolor sp. nov. (Plate XXVIII, figs. A, B, C)

Female: Length about 1.4 mm. Color by direct light, light chestnut brown; eyes, dark red. Head, thorax and abdominal segments 1, 2, 3 a shade darker than rest of abdomen; femora, end of tube, antennal segments 6, 7 concolorous with, or darker than head and thorax; tibiae shading from concolorous with head and thorax at base to pale (concolorous with antennal segments 1 to 5) at end. Subhypodermal pigment of two kinds, red and white; red more dense and conspicuous on periphery of head, all of thorax and abdominal segments 2 and 3, and on sides of abdominal segments 1 and 4 to 8; sparse in fore femora and absent from other femora and abdominal segments 9 and 10; white opaque, visible only by direct light and apparently more dorsal in position than red, present across distal half of pterothorax, all of abdominal segment 4, and on median third of abdominal segments 5 to 8. Pseudo-spiracles indistinctly discernible as more or less clear circular areas on sides of abdominal segments 1 to 8. Ventral surface of whole body smooth; dorsal surface rough, with small setigerous tubercles which are most prominent on head and legs. Narrow anastomosing striae faintly visible on tube and legs.

Head slightly wider basally than length from base to eyes, with vertex produced forward of eyes into a cone which is half as long as the rest of head. Eyes small, more or less circular in outline, consisting of about 10 relatively large facets placed entirely dorsad on the anterior angles of the head. Antennae seven-segmented, inserted ventrally a little inward from anterior angles of the head, with their bases separated by a distinct, short, shallowly emarginate inter-antennal costa. Antennal segments shaped as illustrated; 4 and 5 with two more or less dorso- and ventro-lateral sense cones; 6 and 7 with one cone each; the sense cones and antennal hairs thin, colorless and difficult to distinguish. Mouth cone broadly rounded at end and about two thirds as long from basal suture as distance between this suture and inter-antennal costa. Maxillary and labial palpi clearly two-segmented, with basal segment minute in both cases. Labrum dark and blunt at end, much shorter than labium.

Pronotum about seven-ninths as long as head without vertex, somewhat wider in back than front margin; the sides in reality somewhat concave in the middle as illustrated but, because of an optical effect difficult to explain, seemingly sharply notched above the front edge of the coxae; each hind angle armed with a short, stout, apically expanded seta mounted on a prominent tubercle. Pterothorax just a little shorter than prothorax, considerably wider in back than in front, with sides pronouncedly arched; the dorsum clearly divided into two transverse plates of equal length by a dark suture which arches forward at each end. Legs short and thick; the fore pair somewhat incrassate, and all beset with tubercles of which all but one or two on the inner edge of the fore femora are minute and setigerous. All femora with a long strong hair ventrally near the base. Hind coxae somewhat larger than the others and farther apart, as normal to the family. All tarsi normal, with darkened cup and without claws or spurs.

Abdomen widest at second segment, thence gradually and evenly narrowed to base of 9, which is conical, elongate and more acutely narrowed in its distal half. Segments 3 to 8 of about equal length; their hind angles somewhat produced and each armed with one stout seta which is blunt at the end on all but segments 7 and 8; without marginal or intermarginal hairs, except for two rather long strong ones medianly on the hind ventral margin of segment 8. Tube nearly 1.3 as long as segment 9 and only a sixth as wide as long; gradually widening from the middle to the last fifth and thence more suddenly narrowed again to the end; with four long pale hairs at the tip separated by minor setae.

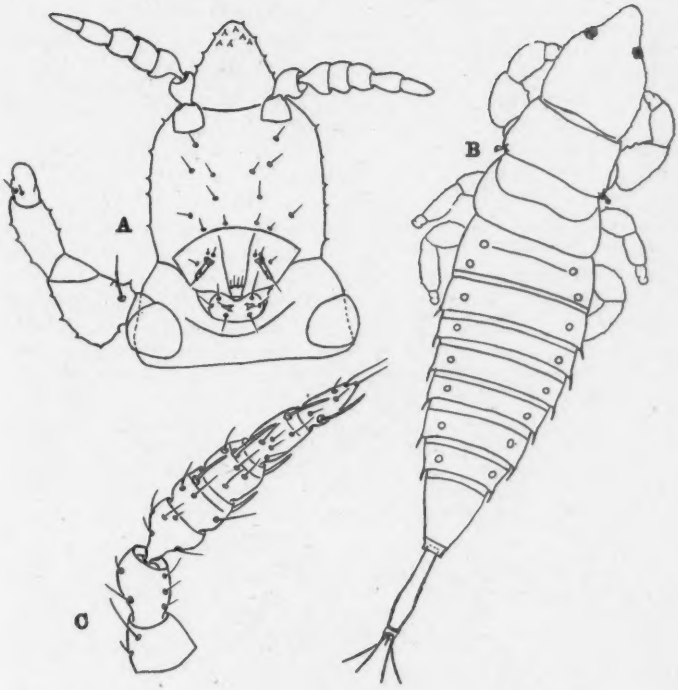

PLATE XXVIII

Conocephalothrips tricolor sp. nov.

A—Ventral view of head and prothorax, showing antennae and right leg.
B—Dorsal view of complete insect, with terminal setae abbreviated.
C—Dorsal view of left antenna.

Measurements of female paratype in mm.:

Antennal segments	1	2	3	4	5	6	7
Length	..	.0369	.0287	.0205	.0246	.0287	.0328
Width	..	.0287	.0287	.0287	.0246	.0164	.0123

Head, median length .225; head, from base to hind corner of eye .147; head width at base .184; head width across eyes .164; mouth cone from basal suture .098; median length of pronotum .114; width of pronotum, including coxae .246; median width of fore femur .073; median length of 9th abdominal segment .143; greatest width of 9th abdominal segment .123; length of tube .192; greatest width of tube, at 4/5 from base, .032; length of longest distal hairs .055; greatest width of abdomen, second segment, .184; length of setae on hind angles of prothorax .020.

Described from two females found on a leaf of *Broussaisia arguta* Gaud., Mt. Kaala, Oahu, on November 3, 1944. Both specimens, type and paratype, have been deposited in the collection of the Hawaiian Sugar Planters' Experiment Station, Honolulu. The male is unknown.

It is of interest to point out that the arrangement of the terminal setae in the new genus is typical of most Tubulifera, unlike that reported in the description of *Urothrips paradoxus* Bagnall. The four major hairs are separated by minor pointed setae dorsally and laterally, and by a pair of minute, blade-like setae (Buffa's "palettes") ventrally. In addition, as further evidence of the now unquestioned tubuliferous nature of the Urothripidae, it is worth noting that the paired pori found on the lateral or dorsal surfaces of the tube in every species of Tubulifera are also plainly visible in the new Urothripid. They are about 4 microns in diameter and close to the sides of the tube, on about the basal third.

As for the unexplained organ which Bagnall noted "on the under side of the ventral plate" of the ninth abdominal segment in *Urothrips paradoxus,* it is also found in my new species and appears to be an internal thickening of the body-wall. Perhaps it serves as a point of attachment for muscles of the ovipositor, or is in some other manner related to this blade-like organ, which in my specimens is visible through the body wall, lying along the midline of the segment and reaching from very near to the above mentioned thickening to the smaller rod-like thickening of the hind ventral margin which marks the genital opening.

Additions to the Thysanoptera from the Island of Hawaii

By FRED A. BIANCHI
H.S.P.A. Experiment Station

(Presented at the meeting of November 19, 1945)

This paper adds 25 species of thrips to the 29 previously listed by Sakimura and Krauss and by Bianchi (Proc. Haw. Ent. Soc., **10**: 1945) from the island of Hawaii. It includes a miscellany of unpublished records accumulated over a period of years in the collections of the writer and others, but is based mainly on the results of extensive and careful collecting which Mr. Clifton J. Davis did during 1945 and the latter months of 1944.

Stationed at Kilauea as park ranger, Mr. Davis is taking excellent advantage of the opportunities afforded by his situation, and his collections and careful investigations have already added greatly to our knowledge of all the orders of insects on the Big Island. In the Thysanoptera his material comprises a great many lots of the more common species, with careful notations as to habits and host plants; but for the sake of brevity only those species are mentioned here which have not been previously recorded from the island.

One of the species is new to the Territory; three are new to science and are now named and described for the first time. With these, the Thysanoptera from the island of Hawaii are run up to 51 specifically determined species, not including several species listed by Sakimura and Krauss only under the generic name, nor two or three species which are represented in my own collection by material too meager to warrant description at present. Since our native thrips appear to be characterized by secretiveness and scarcity, it is very probable that other species, possibly many, remain to be found.

In the following list the initials H.N.P., C.J.D., and F.A.B. refer respectively to the general locality, Hawaii National Park, and to the collectors, Clifton J. Davis and F. A. Bianchi.

Tubulifera

Haplothrips davisi sp. nov. (Plate XXIX, fig. D; Plate XXX, fig. D)

Brachypterous female: Length, not including inter-segmental membranes, about 1.3 mm. Color by transmitted light chestnut brown; extreme base of antennal segment 3, all tarsi and extreme ends of tibiae, lighter. Subhypodermal pigment reddish. Striation very fine, visible only in clear specimens, composed of transverse anastomosing lines, more apparent on dorsum of head, mesoscutum, first abdominal tergite, base of tube.

Head about 1.1 as long as wide, widest in the middle; the cheeks weakly arched to caudal fifth or sixth, which is very slightly narrowed. Vertex declivous to base of antennae, weakly or not at all convex in front. Eyes about one fourth as long as head and about one fourth as wide; dorsally almost semicircular on the inner outline and ventrally weakly, roundly produced at the inner caudal angle. Facets large and regular in size, only about 4 on the outer outline of the eye, a few microsetae among them. Ocelli vestigial or entirely absent. Three or four very minute setae around inner outline of eyes and two on vertex; a few others on cheeks and dorsum of head. Postocular spines more than 1.5 as long as the eyes and set about half the eye length from their posterior margins, a little less than the same distance from the cheeks. Mouth cone about two thirds as long as head, conical, rounded at end; labrum dark-tipped and slightly surpassing labium; maxillary palpi long and thick, about half as long as mouth cone.

Antennae about twice as long as head; the inter-antennal costa short, straight across end and about a fifth as wide as basal antennal segments. Antennal segments as illustrated; the third, fourth, and fifth with wrinkle ventrally near end, upon which are inserted setae somewhat stronger and longer than the others of the segment. Two lateral sense cones on segments 3 to 6 and one dorsad on segment 7; those on segment 4 strong and blunt at end, those on other segments somewhat thinner and more acute. Porus on segment 2 conspicuous. Antennal hairs pale but in general strong and conspicuous.

Prothorax about .9 as long as head and not including coxae about 1.5 as wide as head; the fore and hind margins weakly arched; the sides more strongly divergent from anterior angles to middle than from middle to posterior angles; the median suture short, wavy. The usual major setae pointed, except anteroangulars and anteromarginals which are sometimes blunt or weakly expanded at end; the pair at each posterior angle longest, about equal to one another and to postoculars; midlaterals, anteromarginals and anteroangulars successively shorter; coxals subequal to midlaterals and inserted on the ventral surface of coxae.

Pterothorax subquadrate, about .266 mm. long on midventral line (including first abdominal sternite) and about .254 mm. across anterior angles, very slightly tapered caudally. Fore tibiae and fore femora somewhat thicker than others; fore tarsi armed with the usual claw on the outer surface and a minute tooth on the inner surface of the basal segment.

Abdomen long and heavy, widening gradually to segment 6; major setae light brown, long and pointed; those on segment 9 a little shorter than terminals and 1.5 as long as tube. Tube about .75 as long as head; nearly twice as wide at base as at end and tapering evenly from basal fifth; paired pori conspicuous and on about the distal third of dorsal surface.

Measurements of type (brachypterous female treated with KOH) in mm.: Head length .147; head width across cheeks .143; eye length .036; prothorax length .131; prothorax width including coxae .254; pterothorax length on midventral line .266; pterothorax width on anterior angles .254; abdomen width on segment 6, .299; tube length .110; tube width at base .061; tube width at end .032; longest setae on segment 9, .164; longest setae on tube .184; coxals .164; epimerals .069; posteroangulars .069; midlaterals .061; anteroangulars .032; anteromarginals .045; postoculars .069.

Antennal segments:	1	2	3	4	5	6	7	8	Total
	.028	.041	.041	.041	.041	.041	.041	.028	.302

Brachypterous male: Colored like female; slightly smaller, about 1.12 mm. long. Abdomen equal in width to segment 6, thence tapered caudally. Posteroangular setae on segment 9 reduced (about .036 mm. long), stout and stiff.

Measurements of male allotype (brachypterous; treated with KOH) in mm.: Body length 1.12; head length .123; head width across cheeks .131; prothorax length .102; prothorax width including coxae .221; pterothorax

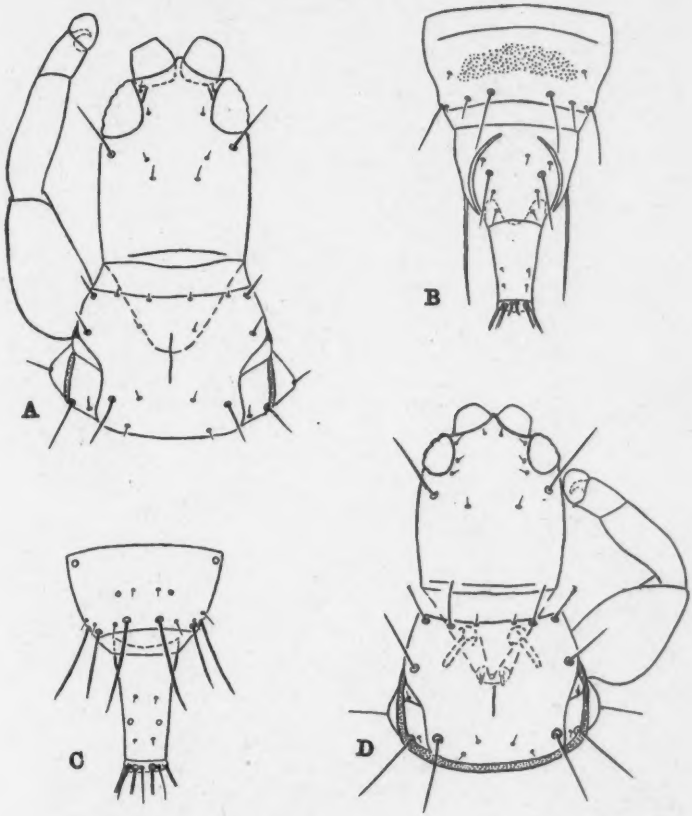

PLATE XXIX

A—*Haplothrips rosai* sp. nov. Head, prothorax and left fore leg of brachypterous female, not showing all minor setae.

B—*Haplothrips rosai* sp. nov. Ventral view of abdominal segments 8, 9, and 10 of brachypterous male, showing median granulose depression on 8th ventrite, terminal bristles abbreviated.

C—*Haplothrips rosai* sp. nov. Dorsal view of abdominal segments 9 and 10 of brachypterous female, with terminal bristles abbreviated.

D—*Haplothrips davisi* sp. nov. Head, prothorax and right fore leg of brachypterous female, not showing all minor setae.

length including first abdominal sternite .205; pterothorax width across anterior angles .213; abdomen width on segment 6, .209; tube length .090; tube width at base .053; tube width at end .028.

Antennal segments:	1	2	3	4	5	6	7	8	Total
	.028	.041	.036	.041	.041	.041	.041	.028	.297

Described from the following material: One female paratype from *Metrosideros* leaves, Kilauea, April 14, 1944, N.L.H. Krauss, coll.; one female paratype from *Acacia koa* branches, H.N.P., March 10, 1945, C.J.D., coll.; male allotype from *Acacia koa* branches, Mauna Loa truck trail, H.N.P., 6,500 ft. elev., April 20, 1945, C.J.D., coll.; one male paratype from dead branch of *Metrosideros,* Makaopuhi, H.N.P., 2,870 ft. elev., July 6, 1945, C.J.D., coll.; two female and two male paratypes on old dead branches of *Pipturus,* Thurston lava tube, H.N.P., July 16, 1945, C.J.D., coll.; three female and four male paratypes on old dead branches of *Sophora chrysophylla,* Mauna Loa truck trail, H.N.P., 5,500 ft. elev., August 24, 1945, C.J.D., coll.; female holotype and one female paratype from dead branch of *Acacia koa,* Mauna Loa truck trail, H.N.P., 6,500 ft. elev., August 25, 1945, C.J.D., coll.

In addition to the type series, I have a number of specimens collected by Mr. Davis on later dates.

Davisi fits well in the *Haplothrips* and, like most species of the genus, it is a difficult one to characterize. However, from other species found in Hawaii it can be separated easily by its long pointed setae, of which only the anteroangulars and anteromarginals on the pronotum are likely to be, but are not always, slightly expanded at the end. It is not without hesitation that I describe it from material which does not include forms possessing functional wings and ocelli, but I feel justified because the species appears to be a common one in the Kilauea region and our collections indicate that it is very probably a prevailingly brachypterous species of which the macropterous forms, if such ever occur, may never be found.

I take pleasure in naming the species after Mr. Clifton J. Davis whose collaboration has made possible the writing of this paper and who has in many ways added to the pleasure of my visits to Hawaii.

Haplothrips rosai sp. nov. (Plate XXIX, figs. A, B, C; Plate XXX, Fig. E)

Brachypterous female: Length not including inter-segmental membranes about 1.43 mm. Color by transmitted light dark chestnut brown; all tarsi light yellowish brown and fore tibiae shading to same color at end. Eyes black; subhypodermal pigment red. Striation fine, composed of transverse anastomosing lines, more apparent basally and laterally on dorsum of head, on abdominal tergite 1, and dorsally at base of tube. All spines clear brownish yellow.

Head about 1.14 as long as wide; the cheeks normally roundly, weakly constricted back of eyes and thence practically straight to base of head, but in some specimens divergent caudally, causing the head to appear widest at

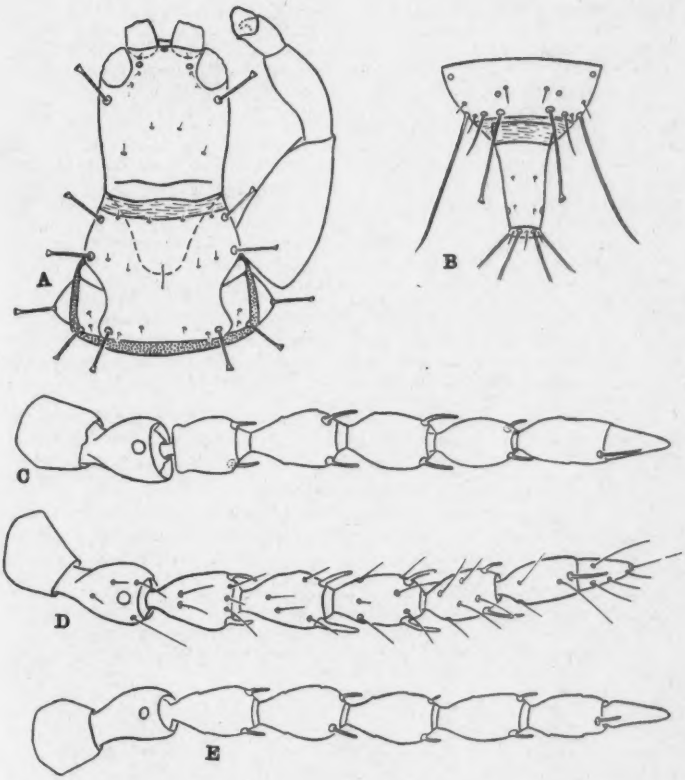

PLATE XXX

A—*Karnyothrips doliicornis* sp. nov. Head, prothorax and right fore leg of brachypterous female, not showing all minor setae.

B—*Karnyothrips doliicornis* sp. nov. Dorsal view of abdominal segments 9 and 10 of brachypterous female, with terminal bristles abbreviated.

C—*Karnyothrips doliicornis* sp. nov. Dorsal view of left antenna of brachypterous female, with all setae omitted.

D—*Haplothrips davisi* sp. nov. Dorsal view of left antenna of brachypterous female.

E—*Haplothrips rosai* sp. nov. Dorsal view of right antenna of brachypterous female, with all setae omitted.

base. Vertex slightly depressed next to eyes; weakly convex dorsally and in front. Eyes large, between one quarter and one third as long as head and nearly one third as wide; dorsally the inner and hind margins forming a distinct obtuse angle; ventrally weakly, roundly produced at the inner caudal angle. Facets small and regular, about 7 occupying the outer outline of eye. Ocelli absent. A few minute setae around inner outline of eye and a few others on vertex, cheeks, and dorsum. Postocular setae about 1.3 as long as eyes and set about .3 the eye length from posterior margin, somewhat closer to the cheek. Mouth cone about .45 as long as head; evenly conical; rounded at end; labrum dark-tipped and just short of labial margin; maxillary palpi long and thick.

Antennae about twice as long as head; inter-antennal costa short, straight across end, only a fourth or fifth as wide as the basal antennal segments. Antennal segments as illustrated; segment 8 constricted at base and narrower than segment 7; segments 3, 4, 5, 6 each with a weak, blunt sense cone on either side; segment 7 with a longer, thinner cone dorsally. Porus on segment 2 conspicuous, about .115 mm. in diameter, placed near distal end of segment. Antennal hairs pale, rather weak.

Prothorax about .8 as long as head and not including coxae about 1.4 as wide; fore and hind margins weakly arched; sides weakly divergent to middle and thence parallel to posterior angles. All setae pointed; anteroangulars and midlaterals about equal to each other, and to coxals, about .5 as long as postoculars, epimerals and posteroangulars; anteromarginals minute. A short wavy median groove is generally apparent.

Pterothorax subquadrate, very slightly tapered caudally, about .205 mm. long on midventral line including first abdominal sternite, about .225 mm. across anterior angles. Wings reduced to short pads. Fore legs a little shorter and thicker than others; fore tarsi without tooth on inner surface, but all tarsi with usual claw on outer surface.

Abdomen long and heavy, widest on segments 4 and 5 which are about equal. Posteroangular setae greatly reduced, sometimes minute, on segments 1 to 7; about half as long as the segment on segment 8; about equal to the segment on segment 9. Terminals about 1.4 as long as tube. Tube somewhat less than twice as long as wide at base and about twice as wide at base as at end, tapering evenly from basal fifth to end and about .7 as long as head. Paired pori about .004 mm. in diameter, placed on about distal fourth.

Measurements of female holotype (brachypterous; treated with KOH) in mm.: Head length .164; head width across cheeks .143; eye length .053; prothorax length .139; prothorax width not including coxae .205; pterothorax length including first abdominal sternite .205; pterothorax width at anterior angles .225; abdomen width at segment 5, .315; tube length .110; tube width at base .061; tube width at end .032; postocular setae .041; anteroangular setae on prothorax .020; midlateral setae .016 (paratype); epimeral setae .041; posteroangular .041; coxal .020; posteroangular on abdominal segment 9, .065; median on abdominal segment 9, .077; terminals on tube .123 (approx.).

Antennal segments:	1	2	3	4	5	6	7	8	Total
	.024	.045	.045	.041	.045	.045	.036	.028	.309

Brachypterous male: Smaller than female, only 1.07 mm. long; of same color and similar in general appearance but with prothorax and tube shorter in relation to head. Distinguished at once from the males of all other *Haplothrips* by a large, more or less reniform, granulose depression medianly located on the 8th ventrite.

Measurements of male allotype (brachypterous; treated with KOH) in mm.: Head length .139; head width .123; prothorax length .102; prothorax width .164; pterothorax length .143; pterothorax width (approx.) .205; abdomen width (segment 5) .217; tube length .082; tube width at base .049; tube width at end .028; postocular setae .041; anteroangulars on prothorax .024; epimerals .041; posteroangulars .041; posteroangulars on segment 9,

.036; medians on segment 9, .065; longest terminals (sides) on tube .123; coxals .016.

Antennal segments:	1	2	3	4	5	6	7	8	Total
	.024	.036	.036	.036	.036	.041	.032	.028	.269

Described from the following material: One female paratype from *Metrosideros* leaves, Kilauea, April 14, 1944, N.L.H. Krauss, coll.; female holotype from dead branch of *Metrosideros,* Makaopuhi, H.N.P., 2,870 ft. elev., July 6, 1945, C.J.D., coll.; one female paratype from *Sadleria* stipes, Makaopuhi, H.N.P., 2,870 ft. elev., July 19, 1945, C.J.D., coll.; male paratype and allotype from leaves of *Vaccinium reticulatum,* H.N.P., March 14, 1945, C.J.D., coll.; one male paratype from dead branch of *Myrsine lessertiana,* Makaopuhi, H.N.P., 2,870 ft. elev., July 16, 1945, C.J.D., coll.

With the heavy abdomen and the caudally widened head, *rosai* does not have the habitus typical of most *Haplothrips* known to me, and perhaps under a more natural classification of the Tubulifera than we now possess the species would not fall into that genus. As it is diagnosed at present, however, the scope of *Haplothrips* does comprehend the whole combination of characters displayed by the new species, which no other genus will quite do.

The granulose depression is plain and fully developed in all male specimens and, to judge by appearances, must serve the same function as the elliptical depressions found on the sternites of many male Terebrantia. I cannot find in the literature any other mention of such an organ in the Tubulifera; but possibly it has been overlooked, as could easily happen in the case of the usual dorso-ventral mounts.

I dedicate this species to Mr. Joseph S. Rosa, who for many years has been my helpful colleague and valued friend.

Haplothrips (Hindsiana) sakimurai Moulton.

One female in dead twigs of *Myoporum sandwicense,* Mauna Loa truck trail, H.N.P., 4,200 ft. elev., July 17, 1945, C.J.D. and F.A.B., colls.

Karnyothrips melaleuca (Bagnall)

One female on dead stipes of *Cibotium chamissoi,* north of sulphur banks, H.N.P., 4,050 ft. elev., July 15, 1945, C.J.D., coll.; two females beaten off dead branches of *Heimerliodendron brunonianum* (Endl.) Skottsb., Kipuka Puaulu, H.N.P., October 11, 1945, C.J.D., coll.; one female beaten off old branches of *Pittosporum convertiflorum* Gray, Pauahi Crater, H.N.P., October 22, 1945, C.J.D., coll.

Karnyothrips flavipes (Jones)

Three males in old branches of *Acacia koa,* Six Tanks, H.N.P., 4,600 ft. elev., November 1944, C.J.D., coll.; two females on dead branches of ohia lehua, Pauahi Crater, H.N.P., December 17, 1944,

C.J.D., coll.; six females on dead branches of *Mezoneurum kauaiense,* east of Puu Waawaa Ranch road, May 26, 1945, C.J.D., coll.; one female in dead twigs of *Myoporum sandwicense,* truck trail, H.N.P., July 17, 1945, C.J.D and F.A.B., colls.; one female on *Macaranga,* Hilo, February 24, 1945, William C. Look, coll. (this is the specimen referred to as *Haplothrips* sp. by Sakimura in the Proc. Haw. Ent. Soc., vol. 12: 331); two females on old branches of *Coprosma* sp., Ohaikea, 4,200 ft. elev., H.N.P., October 13, 1945, C.J.D., coll.; four females beaten off dead branches of *Myrsine sandwicensis* A. DC., Alealea Crater, H.N.P., October 30, 1945, C.J.D., coll.; four females beaten off dead branches of *Myrsine lessertiana* A. DC., Makaopuhi, November 18, 1945, C.J.D., coll.

Karnyothrips doliicornis sp. nov. (Plate XXX, figs. A, B, C)

Brachypterous female: Body length, partly distended, 1.44 mm. Color by transmitted light chestnut brown; middle of tube, tarsi, tibiae, particularly at base and apex, lighter; antennal segments 2, 3, sometimes also base of 4, pale yellowish brown; ocellar crescents, sub-hypodermal pigment red. Striation fine, visible only in cleared specimens, transversely subreticulate on head and mesoscutum, longitudinally reticulate on sides of metanotum.

Head about 1.25 as long as wide; the sides almost straight and parallel from the eyes to about basal fourth, thence weakly and roundly constricted to base; vertex weakly concave next to eyes and weakly convex in middle. Each eye occupying a little less than a quarter head length and a little more than a quarter of head width; the inner dorsal outline irregularly rounded and the inner ventral outline forming an almost right angle; the outer contour protruding very slightly from the vertex and not at all from the cheek; the dorsal facets of same diameter as ocelli and the ventral facets somewhat larger. Ocelli widely separated but not touching inner margins of eyes; the anterior ocellus forwardly directed on declivity of vertex. Postocular spines about .2 longer than eyes, set nearly one third of the eye's length from its margin and about an equal distance from the cheek. One minute spine in front of each posterior ocellus and two on a longitudinal line behind; other very minute spines scattered over dorsum and sides of head. Mouth cone slightly less than half as long as rest of head, much narrower than head at base, broadly rounded at end; labrum blacktipped and not surpassing labium.

Antennae about twice as long as head, inserted a little caudad of vertex; the frontal costa less than half as wide as basal antennal segments, slightly projecting and weakly concave. Antennal segments as illustrated; 3 widened basally at right angles to the pedicel and more or less barrel-shaped above pedicel; 7 not pedicellate and broadly joined to 8. Sense cones weak, only a third or fourth as long as segments bearing them, tapering distally but not sharply pointed; two more or less lateral cones on segments 3 to 6 and one, longer and thinner than the others, on segment 7. Porus on segment 2 conspicuous, about .006 mm. in diameter. Antennal hairs pale, weak, inconspicuous.

Prothorax about .75 as long as head and not including coxae about .6 wider basally than head; the fore and hind margins only weakly arched; the sides more strongly divergent from anterior angles to middle than from middle to posterior angles. Median suture short, wavy. Excepting anterior marginals, all the usual major setae present; all, including prominent coxals, expanded apically, pale, sub-equal in length. Minor setae very small and inconspicuous. Pterothorax normal, about as wide as prothorax at prominent anterior angles and tapering slightly caudally, about .217 mm. long on the

midventral line. Legs rather short and stocky; fore femora slightly incrassate and fore tarsi inconspicuously armed on the basal segment with the usual outer claw and a small inner tooth which sometimes does not surpass the tarsal outline.

Abdomen long and heavy, nearly twice as long as rest of body, widening very gradually to segment seven, thence abruptly narrowed to base of tube. All major setae capitate excepting terminals on tube and laterals on segments 7 and 9. Tube twice as wide at base as at end and nearly twice as long as wide at base, considerably shorter than width of head; the sides parallel on basal fifth (inserted in segment 9) and thence evenly convergent; paired pori on sides of distal fifth; six long terminal setae little less than twice as long as tube.

Measurements of type (apterous female treated with caustic potash) in mm.:

Antennal segments:	1	2	3	4	5	6	7	8	Total
	.041	.045	.036	.045	.045	.036	.053	.032	.333

Body length 1.2; head length .17; head width across cheeks .13; eye length .045; eye width .032; prothorax length .123; prothorax width, including coxae, .254; pterothorax length on mid-dorsal line .184; pterothorax width on anterior angles .246; width of abdomen on segment 6, .266; tube length .106; tube width at base .061; tube width at end .028; postocular setae .049; anteroangulars .041; midlaterals .041; epimerals .049; posteroangulars .041; coxals .041; pointed laterals on segment 7, .102; pointed laterals on segment 9, .135; longest terminals on tube (laterals) .205 (approx.); proximal sub-basal on forewing .032; distal sub-basals on forewing .136.

Macropterous female: Similar to brachypterous form except in the possession of wings and large sigmoid setae paired on abdominal tergites 3 to 7. The forewings are clearly narrowed in the middle and faintly smoky, with the smokiness disappearing near the end. They possess 4 intercallary ciliae, and 3 capitate sub-basals of which the proximal is a trifle shorter than the other pair and the middle one is inserted slightly inward from the others.

Described from the following material, all collected by Mr. Davis: two brachypterous females from dead branches of *Metrosideros*, Makaopuhi, H.N.P., 2,870 ft. elev., July 6, 1945, type and paratype No. 1; one brachypterous female on living branch of *Metrosideros*, Puhinau Crater, H.N.P., October 12, 1944; one brachypterous female on living branch of *Sophora chrysophylla*, near Kipuka Ki, H.N.P., 4,500 ft. elev., December, 1944; one brachypterous female on *Sadleria* stipes, near Makaopuhi, H.N.P., 2,860 ft. elev., December, 1944, paratype No. 2; one macropterous female, host unrecorded, H.N.P., December 12, 1944, paratype No. 3.

In addition to the type series, I have two brachypterous females collected by Davis on *Myoporum sandwicense*, dead wood, at Keauhou Ranch, 4,200 ft. elev., July 23, 1945, and two brachypterous females beaten off dead branches of *Myrsine lessertiana* at Makaopuhi, H.N.P., on November 18, 1945.

The habitus of this new species is typical of the genus and it might be mistaken in Hawaii for *Karnyothrips flavipes* (Jones) if it were not for the very distinctive antennae and the inner tooth of the fore tarsus, which is much shorter in *doliicornis* and sometimes hardly surpasses the contour of the tarsus. To judge by the illus-

trated description, *Zygothrips pallidus* Hood has very similar antennae, but in other respects the two species are quite different.

Hoplothrips swezeyi Moulton

One male under bark of *Metrosideros,* Hiiaka Crater, H.N.P., December 17, 1944, C.J.D., coll.

Phloeothrips mauiensis Moulton

One male and two females on old branches of *Sophora chrysophylla,* Kipuka Ki, H.N.P., December 17, 1944, C.J.D., coll.; one female on old branch of *Pittosporum convertiflorum* Gray, Pauahi Crater, H.N.P., October 22, 1945, C.J.D., coll.

Macrophthalmothrips hawaiiensis Moulton

Four females in old branches of *Sophora chrysophylla,* Kipuka Ki, H.N.P., 4,500 ft. elev., November 6, 1944, C.J.D., coll.; two males and one female in old branches of *Acacia koa* near Six Tanks, H.N.P., November, 1944, C.J.D., coll.; one male and one female under bark of *Sapindus saponaria* Linn., H.N.P., January 31, 1945, C.J.D., coll.; one female in old branches of *Acacia koa,* H.N.P., February 10, 1945, C.J.D., coll.; one female on old branch of *Xylosma hawaiiensis* Seem. var. *hillebrandii* (Wawra) Sleumer, Kipuka Puaulu, H.N.P., October 11, 1945, C.J.D., coll.; one male beaten off dead branches of *Perottetia sandwicensis* Gray, N.W. of Keauhou Ranch, October 19, 1945, C.J.D., coll.

Podothrips lucasseni (Kruger)

Many males and females on sugar cane, Honokaa, October 15, 1924, C. E. Pemberton, coll.

TEREBRANTIA

Chirothrips mexicanus Crawford

Five females by sweeping grass, Six Tanks, H.N.P., January 1, 1945, C.J.D., coll.

Chirothrips fulvus Moulton

One female beaten off dead leaves of *Styphelia tameiameiae,* end of Mauna Loa truck trail, 6,500 ft. elev., H.N.P., October 12, 1945, C.J.D., coll.

Hercothrips fasciatus (Pergande)

Abundant on leaves and stems of *Argemone glauca* and of *Sonchus oleraceus,* near Naalehu, June 5, 1945, F.A.B., coll.

Hercinothrips femoralis (Reuter)

One female on grass, Six Tanks, H.N.P., January 31, 1944, C.J.D., coll.

Scirtothrips antennatus Moulton

Small colony, females and young, on leaves of *Plumeria,* Hono-

kaa, March 29, 1944, F.A.B., coll.; small colony on leaves of *Colubrina oppositifolia* Brongn., Puu Waawaa, 1,900 ft. elev., C.J.D., coll.

Anaphothrips swezeyi Moulton

Abundant on sugar cane and grass, Honokaa, October 19, 1924, C. E. Pemberton, coll.

Thrips saccharoni Moulton

Abundant on sugar cane, Honokaa, February 26, 1923, C. E. Pemberton, coll.

Merothrips morgani Hood (Proc. Ent. Soc. Wash., **14**: 132, 1912)

One female beaten off dead branch of *Santalum paniculatum* Hook. & Arn., Kipuka Puaulu, H.N.P., October 11, 1945; five females and one male beaten off dead branches of *Heimerliodendron brunonianum* (Endl.) Skottsb., same date and locality as above; one female beaten off branches of *Urera sandwicensis* Weddell, same date and locality as above; two females and one male beaten off dead branches of *Perottetia sandwicensis* Gray, 1¼ miles N.W. of Keauhou Ranch, October 19, 1945; two females and one male beaten off dead branches of *Pittosporum convertiflorum* Gray, Pauahi Crater, H.N.P., October 22, 1945; all collected by Mr. Davis.

Perfect agreement of all these specimens with Hood's careful, illustrated description leaves no doubt of their identity. This wingless species was described from Illinois and Kentucky and its discovery in Hawaii, constituting a new record for the Territory, suggests that the species is probably more abundant and of wider range on the American continent than is shown by published records. It is improbable that such a species could have reached Hawaii from the eastern United States without also spreading its range to the west coast.

Comparison of Mr. Davis' specimens with a paratype of the winged *Merothrips hawaiiensis* Moulton (Proc. Haw. Ent. Soc., **9** [3]: 411, 1937) borrowed from the collection of the Pineapple Research Institute, Honolulu, shows a very close resemblance of the two species and indicates that they may be but the winged and the wingless forms of a single species. Until the two forms are collected together, however, or at least on the same island, their synonymy will remain doubtful.

Thrips (Isoneurothrips) australis Bagnall

One female from a flower of *Pittosporum undulatum* Vent., residential area, H.N.P., March 14, 1945, C.J.D., coll.

Thrips (Isoneurothrips) carteri Moulton

End of Mauna Loa truck trail and Kipuka Ki, H.N.P., at elevation of 6,400 and 4,200 ft. respectively, on several dates, C.J.D. and F.A.B., colls.

In contrast to other *Isoneurothrips,* which are mostly collected in flowers, colonies of this species are often found associated with a rust fungus very common on *Acacia koa.* The relationship of the two organisms has not been worked out, but cursory observations indicate that the thrips probably lay their eggs among the massed spores of the fungus—"the rust"—and that the larvae feed on some exudation either of the fungus or of the host plant.

Thrips (Microcephalothrips) abdominalis Crawford

Numerous on flowers of *Erigeron,* near Kiholo, July 7, 1945, F.A.B., coll.

Taeniothrips gracilis Moulton

Abundant in all stages and feeding heavily on leaves and stems of *Crinum* sp., Pololu Valley, June 28, 1944, F.A.B., coll.

I have found this species hidden within the unopened flowers of the same host plant at Halawa Valley, Molokai, where the thrips were apparently not numerous enough to hurt the plant. Heavy injury is accompanied by extensive reddish discoloration of the plant.

Taeniothrips frici (Uzel)

Numerous on flowers of *Hypochoeris radicata* Linn., Mauna Loa truck trail, H.N.P., February 25, 1945; one female on dead branch of *Acacia koa,* same locality, August 8, 1945; two females beaten off dead leaves of *Styphelia tameiameiae* (Cham.) F. Muell., same locality, October 12, 1945; all collected by Mr. Davis.

Taeniothrips cyperaceae Bianchi

One female on leaves of *Vinca major* L., residential area, H.N.P., March 11, 1945, C.J.D., coll.

Frankliniella near **sulphurea** Schmutz

This is the species which was first found during August of 1942 and which has since become a predominant species on Oahu. I presume it is the same species listed by Sakimura as *"Frankliniella* sp." from the island of Hawaii (Proc. Haw. Ent. Soc., **12**[2] : 329) but I cannot find a more specific reference to its presence on that island. For the sake of an unmistakable record, therefore, I note here that the species is found on Hawaii and that it is quite common on the lowlands, although it does not appear to have attained the predominant position it has on Oahu. Mr. Davis collected the species from flowers of *Lantana, Hibiscus,* and monkeypod at Keauhou, Kona, during May of 1945, and I had previously found it on other hosts in two localities of the island, both under 2,000 ft. elevation.

Host Records of Philaenus spumarius (Linn.) at Kilauea, Hawaii National Park (Homoptera: Cercopidae)

By C. J. DAVIS and A. L. MITCHELL

(Presented at the meeting of August 13, 1945)

The family Cercopidae is represented in Hawaii by the single immigrant species *Philaenus spumarius* (Linn.). This spittle-insect was first seen in the islands by Warren Goolsby, who collected it from daikon (*Raphanus sativus* Linn. *longipinnatus* Bailey) and satsuma orange leaves near the Volcano House, Kilauea, Hawaii, on January 17, 1944 (Proc. Haw. Ent. Soc., 12:219, 1945; as *P. leucophthalmus* [Linn.]). Herbert Osborn (Meadow and Pasture Insects: 101, 1939) states that *P. spumarius* "is a very widely distributed species both in Europe and America, and in the United States and Canada occupies a large area from the Atlantic coast to the plains regions." It probably reached Hawaii from the mainland of the United States on imported plant material in recent years. The present authors have observed it abundantly in Kipuka Puaulu (Bird Park), the administrative and residential area, Kipuka Ki, at the Hilo entrance to the park, and at the Kilauea Ranger Station (29 miles).

Nymphs immersed in froth have been commonly found on leaves and stems of a large number of different plants, though no injury to the infested plants has been observed. The adults are often found on vegetation near the infested foliage, or on the same plants occupied by the nymphs. A record has been kept of all plants on which the authors have observed froth masses. This is given below.

We are grateful to Dr. O. H. Swezey for identifying the insect and to Mr. C. E. Pemberton for encouragement and suggestions.

Host	Location	Date
Saccolepis contracta	Nursery	Jan. 30, 1945
Centaurium umbellatum	Nursery	Jan. 30
Ilex anomala§	Crater Rim Road	Jan. 30
Hibiscus tiliaceus§	Nursery	Jan. 30
Hypochoeris radicata	Hilo entrance	April 3
Rubus penetrans*†	Hilo entrance	April 3
Digitaria pruriens	Hilo entrance	April 3
Trifolium procumbens	Hilo entrance	April 3
Plantago lanceolata	Hilo entrance	April 3
Geranium carolinianum var. **australe***†	Hilo entrance	April 3
Verbena litoralis†	Hilo entrance	April 3
Mentha sp.†	Kipuka Puaulu	April 3

* Previously recorded by N. L. H. Krauss (Proc. Haw. Ent. Soc., 12:220, 1945).
† Preferred host.
§ Indigenous host.

Host	Location	Date
Brassica oleracea var. **botrytis**	Quarters 22	April 17
Lactuca sativa	Quarters 22	April 17
Medicago hispida	Quarters 31	May 11
Mesembryanthemum sp.*	Quarters 31	May 11
Senecio mikanioides	Quarters 31	May 11
Tibouchina semidecandra	Quarters 31	May 11
Gnaphalium purpureum	Quarters 31	May 11
Dianthus chinensis	Quarters 31	May 11
Coprosma rhynchocarpa*§	Kipuka Puaulu	May 15
Veronica plebeia	Kipuka Puaulu	May 15
Modiola caroliniana	Kipuka Puaulu	May 15
Commelina diffusa	Kilauea ranger sta.	May 17
Chrysanthemum maximum	Kilauea ranger sta.	May 17
Vinca sp.	Kilauea ranger sta.	May 17
Panicum purpurascens	Kilauea ranger sta.	May 17
Sonchus oleraceus	Kilauea ranger sta.	May 17
Tritonia crocosmaeflora	Kilauea ranger sta.	May 17
Erigeron albidus	Headquarters bldg.	May 18
Oenothera striata	Observatory	May 18
Cordyline terminalis	Quarters 20	May 19
Myosotis azorica	Quarters 7	May 20
Cyperus brevifolius	Quarters 7	May 20
Cynodon dactylon	Quarters 7	May 20
Hebe salicifolia	Quarters 7	May 20
Anagallis arvensis	Kipuka Puaulu	May 21
Dactylis glomerata	Kipuka Ki	May 26
Rheum rhaponticum	Quarters 21	May 27
Holcus lanatus	Kipuka Puaulu	May 31
Lythrum maritimum	Residential area	June 11
Fuchsia magellanica*	29 Miles	June 11
Wikstroemia phillyreaefolia§	Nursery	June 13
Raillardia scabra§	Nursery	June 13
Coprosma ernodeoides var. **typica**§	Nursery	June 13
Artemisia vulgaris	Adm. area	June 29
Dahlia sp.	Quarters 22	July 2
Hypericum moserianum	Quarters 2	July 4
Pastinaca sativa	CCC camp	July 11
Coix lacryma-jobi	CCC camp	July 11
Solidago altissima	Residential area	Sept. 1
Physalis peruviana*	CCC camp	Oct. 9
Bidens pilosa var. **minor**	Quarters 22	Oct. 13
Rumex acetosella	Quarters 22	Oct. 13
Daucus carota var. **sativa**	Quarters 21	Oct. 23
Ipomoea batatas	Quarters 22	Nov. 1
Pluchea odorata	CCC camp	Dec. 31
Metrosideros collina var. **polymorpha**§	Nursery	Jan. 10, 1946

* Previously recorded by N. L. H. Krauss (Proc. Haw. Ent. Soc., 12:220, 1945).
§ Indigenous host.

On the Species of Araecerus Schoenherr, 1823, Known from the Hawaiian Islands

(Coleoptera: Anthribidae)

By H. E. KARL JORDAN, Ph.D., F.R.S.
Zoological Museum, Tring

(Presented at the meeting of November 19, 1945)

The present account of the Hawaiian *Araecerus* is based on some 180 specimens, of which 110 have been entrusted to me for determination by the Bernice P. Bishop Museum, the others (mostly collected by Blackburn and Perkins) being the property of the British Museum (Natural History). This material was obtained on the six main islands: Hawaii, Maui, Lanai, Molokai, Oahu and Kauai. The genus, however, may be expected to occur also on some of the small outlying islands, such as Laysan, which have some vegetation.

Araecerus is an Old World genus, numerous in species, most of which are Oriental, only a few being known from the Aethiopian region. On the American continents only one species is found, *A. fasciculatus,* which has become cosmopolitan with the trade in coffee beans. This name was applied by Blackburn and Sharp (in 1885) to all the specimens which Blackburn had found on the Hawaiian Islands, and in 1900 Perkins followed their example, adding to the fauna a conspicuous new species he had discovered on Hawaii. In reality, the specimens considered to be *A. fasciculatus* represented three species, as is proved by the Blackburn and Perkins material before me. The oversight on the part of these authors is readily excused: at that time the descriptions of species of *Araecerus,* with some exceptions, were very superficial, the trenchant distinctions not being known. The specific differences in structure are mainly found on the under side, and as the specimens in collections are generally so mounted that the under side is concealed, it is not to be wondered at that these differences escaped notice. Errors in the determination of *Araecerus* are in consequence of frequent occurrence. For instance, I have had in the collection at Tring for many years a species as *Araecerus koebelei* Blackburn, 1900, which is not *koebelei* at all, as I saw at a glance when the transfer of the British Museum Anthribidae to Tring for amalgamation with my collection (presented to the British Museum) gave me an opportunity to turn the type of *A. koebelei* over

and look at its under side. A similar mistake caused by the inconvenient mounting of the specimens was made by O. H. Swezey, who, in 1934, recognized *A. vieillardi* Montrouzier, 1860, as a third species among the Hawaiian *Araecerus,* but accepting the determination, by previous authors and himself, of the commonest species as *A. fasciculatus,* was misled by great superficial similarity to regard as *A. vieillardi* a series of specimens of which some were *vieillardi* and others were true *A. fasciculatus.*

The Hawaiian *Araecerus* before me represent four species: two being indigenous and not known from elsewhere (*A. constans* Perkins, 1900, evidently a rarity and almost constant in coloring, and a new species, very variable and distributed over the archipelago), and two accidentally introduced (*A. fasciculatus* [Degeer 1775], cosmopolitan, and *A. vieillardi* [Montrouzier 1860] from the islands of the Pacific, exact westward distribution not yet known).

In consequence of the misidentifications referred to above, the records of habits and other biological details have lost most of their value. New observations are necessary. I have compared the records in the Proceedings of the Hawaiian Entomological Society with the labels on the specimens and found out in some instances to which particular species the published note applies. Perhaps Mr. E. C. Zimmerman will be successful in obtaining the original specimens on which the biological records were based. Two of the four Hawaiian *Araecerus* are common and easy to breed, and there is a great opportunity to study the larvae and discover specific differences in their morphology and perhaps their habits which would be of much value.

The majority of species of *Araecerus* are more easily recognized by the males. Determination, therefore, should generally be based on the male. In all true *Araecerus* the sexes are distinguished from each other by the last external segment: its tergum (pygidium) is more or less vertical in the male, with the apex rounded, and the sternum about as long medianly as the previous one; the antenna is somewhat longer, the fore tibia and fore tarsus are long-hairy beneath and prolonged, the tibia bearing, in three of the Hawaiian species, prominent tubercles on the underside, and in one (*A. vieillardi*), an apical mucro in addition. In the female the pygidium is longer, triangular, with the margin of the tip somewhat curved up, the last external sternum being much longer medianly than the preceding segment; in many females the ovipositor projects more or less from the anal segment; the foreleg, though longer than the midleg, is not long-hairy beneath and bears no tubercles in the female of any species. The organs of reproduction are not referred to here; their differences will be better understood in a survey of the whole genus.

Key to the Hawaiian Species

A. Males

a. Fore tibia with apical mucro on under side.....**vieillardi** (Montrouzier).
Fore tibia without apical mucro..... b

b. Fore tibia without prominent tubercles on under side; midcoxa without a tubercle.....**fasciculatus** (Degeer).
Fore tibia with tubercles on under side from near base to apex..... c

c. Coloring of upper side very variable, subbasal swelling of elytra distinct; tibiae more or less blackish on upper side in middle.....**varians,** new species.
Almost uniformly grey on upper side, subbasal swelling of elytra less distinct, the insect more evenly convex in lateral aspect, broader and larger than *A. varians,* tibiae uniform in color, or darkened at apex.....**constans** Perkins.

B. Females

a. Prosternum centrally rough with large punctures and tubercles.....**vieillardi** (Montrouzier).
Central area of prosternum without large punctures, at most with small ones along anterior margin..... b

b. Tibiae with four blackish (or brown) spots: basal, antemedian, postmedian and apical; sculpture of pronotum and elytra as coarse as in *A. vieillardi*.....**fasciculatus** (Degeer).
Tibiae without dark spots, or without basal spot and with the ante- and postmedian spots confluent; sculpture of upper side less coarse c

c. Subbasal swelling of elytra very distinct in lateral aspect, pronotum and elytra from behind subbasal swelling to near apex less convex than in the two preceding species, tibiae with large blackish median spot on upper side, first and second abdominal segments with fewer than five rows of punctures each side and the median rows sublaterally missing; color as in male.....**varians,** new species.
Larger and broader, subbasal swelling of elytra less distinct, tibiae not spotted, abdominal sternum I with five irregular rows of large punctures from side margin, II and IV with six to eight, sublaterally no large space devoid of punctures; upperside colored as in male.....**constans** Perkins.

1. **Araecerus constans** Perkins

Areocerus constans Perkins, Fauna Hawaiiensis 2 (3) : 182, 1900 (Hawaii: Kona, in flowers of white poppy).

Araecerus constans Perkins, Zimmerman, Proc. Hawaiian Ent. Soc. **10**: 152, 1938 (key to Hawaiian Anthribidae).

Larger than the other Hawaiian *Araecerus,* pronotum and elytra together twice as long as broad, sculpture of upper surface less coarse than in *A. fasciculatus,* pubescence uniformly grey, with indications of grey spots on the elytra. Club of antenna less unsymmetrical than in *A. fasciculatus,* the proportional length (in male) of the three segments: IX 27, X 24, XI 30, width 14. Lateral angle of pronotal carina a little more than 90°, the lateral carina slightly more slanting than in *A. fasciculatus.* Subbasal swelling of elytra less elevate than in *A. varians,* the upper surface being more evenly convex in lateral aspect. Central antecoxal area of prosternum somewhat uneven with low swellings and small punctures and tubercles; midcoxa of male with a low transverse tubercle. Punctures at side of abdomen more

numerous than in the three other species. Tibiae rufescent or dark brown (discolored ?), without dark spots, fore tibia of male with distinct tubercles on inner side. Length 4.2 to 5 mm.

One male examined from Bishop Museum [plus four examples not seen by Jordan, E. C. Z.]. In British Museum three males and five females, original specimens collected by Perkins; the species does not seem to have been met with again. A card bearing a male and a female is marked "type". I select the male as the type. The card bears a crossed-out name which is preoccupied in *Araecerus;* mentioning the name would create an unnecessary synonym of *A. constans.* [Some of the Bishop Museum set also bear this name, E. C. Z.]

2. **Araecerus varians,** new species (fig. 1, A)

Curculio fasciculatus Degeer, Blackburn and Sharp, Trans. Royal Dublin Soc. (2) 3 : 195, 1885 (Hawaii, Maui, Lanai, Oahu, Kauai; has no saltatory power whatever; partim).

Araeocerus fasciculatus (Degeer), Perkins, Fauna Hawaiiensis 2 (3) : 182, 1900 (partim).

Figure 1.—Outlines of terminal segments of antennae of the males of three species of *Araecerus,*—A. *A. varians,* new species; B. *A. fasciculatus* (Degeer); C. *A. vieillardi* (Montrouzier). Hairs and bristles omitted.

Closely agreeing with *A. constans* in structure. Smaller, but the largest individuals attaining the length of the smallest example of *A. constans* known to me. Subbasal swelling of elytra much more raised, the elytra, in lateral aspect, therefore, from this point backwards more slanting and flatter than in the other Hawaiian species, the swelling more glossy; disk of pronotum more flattened, angle of carina as in *A. constans,* lateral carina straighter; club of antenna a little broader than in *A. constans,* proportions in males 30, 24, 27, width 14. Central antecoxal area of prosternum nearly as smooth as in *A. fasciculatus,* with some small tubercles in front of coxae; abdominal sterna with fewer punctures than in *A. constans,* segment I bearing only four rows at sidemargin and the median rows disappearing about halfway between sidemargin and trochanter, leaving a fairly large area devoid of punctures except at margins; tibiae of well-preserved mature specimens with a large, diffuse dark median patch on upper side. In male the fore tibia with two rows of tubercles on inner surface (not very prominent in small males), no apical mucro; midcoxa with a low transverse tubercle or ridge. Pubescence of upper side very variable in color, the varieties connected by intergradations: elytra brown variegated and dotted with grey, somewhat as in *A. fasciculatus,*

but the alternate interspaces not contrasting as in that species,—or elytra grey with three transverse brown bands or patches,—or elytra brown with a grey lateral stripe from base to apex,—or elytra brown mottled with grey and bearing a grey sutural stripe,—or upper side grey with the side of the pronotum and a lateral well-defined patch on the elytron brown. Length 2.8-4.2 mm. (pronotum and elytra together).

Type in British Museum, from Maui: Iao Valley, March, 1894 (Perkins), a male with grey dots on elytra. 103 specimens examined (paratypes).

Hawaii: South Kona, November, on *Clermontia* (Swezey coll.); Kilauea, July, and Kona, June, July and September (Perkins coll.).

Maui: Kailua, June, on *Elaphoglossum* and *Straussia,* Halehaku, June, and Wailunanui, July (Bryan coll.); Haleakala, 3-4000 ft., March and April, 5000 ft., March and May (Perkins coll.).

Molokai: Kalae, August (Perkins coll.); Kalihuki, 3800 ft., August, on Hilo grass (C. M. Cooke, Jr., coll.).

Lanai: 2000 ft., December and January, and Halepaakai, July (Perkins coll.).

Oahu: Near Honolulu, May; Waianae Mts., April, 2-3000 ft., Nuuanu Valley, November (Perkins coll.); Kaumuahona, June (Bridwell coll.); S. Waianae Mts., November (Swezey coll.).

Kauai: Kaholuamano, 4000 ft., Halemanu, 4000 ft., May, and high plateau, August (Perkins coll.); Kumuwela, on *Cyanea* and *Pipturus,* August (Swezey coll.).

3. **Araecerus fasciculatus** (Degeer) (fig. 1, B)

Curculio fasciculatus Degeer, Mem. Hist. Nat. Ins. **5**: 276, pl. 16, fig. 2, 1775.

Araecerus (*Curculio*) *fasciculatus* Degeer, Lucas, Ann. Soc. Ent. France, (4) **1**: 404, 1861 (partim; synonymy, *fasciculatus* for the first time identified with *cacao* and *coffeae* of Fabricius).

Araeocerus fasciculatus (Degeer), Swezey and Bryan, Proc. Hawaiian Ent. Soc. **7**: 299, 1929 (Molokai: in husk of kukui nut [*Aleurites moluccana*], partim).

Araecerus vieillardi (Montrouzier), Swezey ibid., **9**: 17, 1934 (partim).

In both introduced species the net-like sculpture of the pronotum and the granulation of the elytra are coarser than in the two indigenous ones, the elytra are more cylindrical and the sides of the pronotum more swollen; tibiae quadrimaculate. Size variable, but coloring of upper side nearly constant in the Hawaiian Islands, russet brown, clouded and spotted with grey pubescence.

In *A. fasciculatus* head and rostrum grey, with some brown markings shining through: on rostrum a subapical transverse band medianly enlarged backwards, on frons each side a patch separate from eye, on occiput a pair of smaller patches nearer together, in many specimens these markings diffuse or are obsolescent; apical area of pronotum grey, usually with a marginal brown spot each side of a grey median dash, rest of pronotum suffused with

grey, in some specimens with the spots more distinct; on elytra a distinct but ill-defined grey patch above shoulder and another at apex, and in many individuals a short grey sutural stripe behind scutellum, alternate interspaces somewhat contrasting in an aspect from front, III, V, VII and IX being feebly convex and bearing each 5 to 7 grey spots. Club of antenna unsymmetrical, more so in male than in female, proportions of IX-XI: 30, 27, 27, width 13. Central antecoxal area of prosternum smooth, at most with some small punctures at anterior margin. Puncturation of abdomen essentially as in *A. varians*. Midcoxa of male without tubercles and anterior tibia without rows of tubercles present in the other three species, no apical mucro. Length (pronotum and elytra together) 2.3 to 4 mm., but more dwarfed specimens may be expected to occur (as elsewhere).

Forty-seven specimens, all but three in Bishop Museum:

Maui: Iao Valley, December, on coffee tree (Bryan coll.).

Molokai: Kainalu, July, kukui nut and *Cassia occidentalis* (Bryan coll.).

Oahu: Honolulu (Hawaii Agric. Exper. Station), star apple, April, University of Hawaii farm, October, Bishop Museum, June, Honolulu, February, Kawailoa, June, Waialae Iki, November, Oahu Plantation, Waipio, September, Ewa coral plain, on *Morinda*, December (Bryan coll.); Honolulu, no date, Palolo, February (Illingworth coll.); Honolulu, in algaroba seeds, April (Perkins coll.); Keakakei Valley, on a lobelioid, June, (Adamson coll.); Palolo, ex koa, January (Young coll.); Mokuleia, on breadfruit, March, (Wilder coll.); Manoa, February, and Honolulu, October (Ball coll.); Tantalus, no date, no collector.

Kauai: Ahukini, sugar cane, July, and Lihue, ex sun flower, August (Bryan coll.).

In British Museum 3 specimens collected by Blackburn, one of them labelled Oahu.

Whereas Blackburn emphatically states that what he identified as *A. fasciculatus* has no saltatory power, observers in other parts of the world report that *A. fasciculatus* is very lively and makes jumps 2-3 cm. high and 4 cm. wide. Perhaps *A. varians* does not jump, which would be an interesting distinction.

4. **Araecerus vieillardi** (Montrouzier) (fig. 1, C)

Curculio vieillardi Montrouzier, Ann. Soc. Ent. France (3) **8**: 873, 1860 (New Caledonia; footnote: "Genre *Araeocerus*").

Araeocerus fasciculatus (Degeer), Swezey and Bryan, Proc. Hawaiian Ent. Soc. **7**: 299, 1929 (Molokai, in husks of kukui nut; partim).

Araecerus vieillardi (Montrouzier), Swezey, ibid, **9**: 17, 1934 (specimens in collection Hawaiian Sugar Planters'; partim, some being *A. fasciculatus*).

In general appearance and the coarse sculpture of pronotum and elytra resembling *A. fasciculatus* so much that the two species are easily mixed up. It is fairly easy, however, to distinguish one from the other by a comparison

of the antennae, the forelegs and the underside of the thorax. Club of antenna shorter, the segments almost symmetrical, proportional length in male 25, 20, 22, width 15 (measurements varying in all four species); central antecoxal area of prosternum uneven, with tubercles and some large punctures; in male the midcoxa with a distinct conical tubercle and the fore tibia on innerside with an apical mucro and two rows of tubercles, which are readily visible in a lateral view of the tibia.

In the Bishop Museum material examined are 13 specimens; in British Museum 6, of which 5 collected by Blackburn are left without indication of the island and one (Perkins coll.) was obtained on Oahu.

Molokai: Kainalu, kukui nut, and at sea level, July (Bryan coll.).

Oahu: Koko Head, no date (Illingworth coll.); Rooke Valley, November (Swezey coll.); Kawailoa, June, and Honolulu, August (Bryan coll.); Nuuanu Valley, May (Perkins coll.).

Kauai: Haena, August, Lihue, September, and Summit camp, September (Swezey coll.); Honopu, June (Bryan coll.).

The original home of *A. fasciculatus* was India or Africa, whereas *A. vieillardi* is essentially an inhabitant of the Pacific. There might be an opportunity for a Japanese species (described by Sharp in 1891 as *A. tarsalis,* a species found among beans by Lewis) to invade the Hawaiian Islands. This species is similar to *A. vieillardi,* but is darker, generally more regularly maculate on the elytra, segments IV and V of the antenna are together but little longer than III, the angle of the pronotal carina is smaller (more acute), the tarsi are broader, particularly in the male, the fore tibia of the male has no mucro, etc.

Records of *Araecerus* in the Proceedings of the Hawaiian Entomological Society:

Araeocerus fasciculatus, Giffard **1**: 181, 1908 (Lanai, beaten from kukui).

Araecerus fasciculatus, Bridwell **4**: 22, 1919 (imago of hymenopteron *Perisierola emigrata* eating larva).

Araecerus fasiculatus (!), Bridwell, loc. cit.: 407 (near Pearl City, pods of *Samanea saman* attached).

Araeocerus fasciculatus, Swezey, ibid.: 452, 1921 (Sugar Loaf Hill and Waianae Mts., description of eggs found in koa pods, probably this species, but see also note below).

Araeocerus fasciculatus, Swezey **5**: 15, 1922 (one specimen bred from *Sicana odorifera*).

Araeocerus fasciculatus, Swezey loc. cit.: 187, 1923 (eggs described in 1921 not this species).

Areocerus (!) *fasciculatus,* Swezey **6**: 233, 1923 (one specimen bred from rotten branches of *Plumeria*).

Araecerus fasciculatus, Swezey and Bryan, loc. cit. : 417, 1927 (Molokai, one at Kamiloloa).

Araecerus fasciculatus, Illingworth, **7**: 44, 1928 (Lanai).

Araecerus fasciculatus, Illingworth loc. cit. : 250, 1929 (Kona, Hawaii, in and about cotton bolls).

Araecerus fasciculatus, Swezey and Bryan ibid. : 299, 1929 (Molokai, 11 at sea level to 100 ft., husks of kukui nut, etc.; 1 at Kamiloloa [Adamson]).

Araecerus fasciculatus, Illingworth, ibid. : 409, 1931 (Waipio, in water of Waiahole ditch).

Araecerus fasciculatus, Swezey ibid. :498, 1931 (Maui, on *Cheirodendron gaudichaudii*).

Araecerus vieillardi, Swezey, **9**: 17, 1935 (among *A. fasciculatus* in H.S.P.A. collection, list of localities).

Araecerus vielliardi, id., loc. cit. (misprint).

Araecerus fasciculatus, Swezey, **9**: 201, 1936 (food plants of larvae in Hawaii).

Araecerus fasciculatus, A. vieillardi, and *A. constans,* Zimmerman **10**: 152, 1938 (the genus represented in Hawaii by three described species and some new species).

Araecerus fasciculatus and *A. vieillardi,* Marlowe, ibid. : 359 (Waimea, larvae in green and in ripe fruit of *Passiflora laurifolia*).

Araecerus fasciculatus and *A. vieillardi,* Swezey, ibid. : 362, 1940 (Oahu, from bunch of bananas in his garden).

Araecerus vieillardi, Swezey ibid. : 366, 1940 (reared from banana bunch, Manoa Valley, Oahu).

Araecerus fasciculatus, Sakimura and Linford, ibid. : 452, 1940 (Lanai, ripe pineapple fruit and old fruits of *Melia azedarach*).

Areocerus sp., Holdaway and Nishida, **11**: 167, 1942 (Oahu, Ewa Plantation, September, in freshly threshed dry beans).

Araecerus fasciculatus and *A. vieillardi,* Holdaway and Look, ibid. : 257, 1942 (Hawaii Agric. Exper. Station, dry garden beans).

Araecerus fasciculatus and *A. vieillardi,* Krauss, **12**: 88, 1944 (Maui; Molokai).

Araecerus fasciculatus, Swezey, **12**: 358, 1945 (intercepted in California on *Dendrobium macrophyllum* from Borneo).

The Identity and Host Plants of Blossom Midge in Hawaii[1] (Diptera: Cecidomyiidae: Contarinia)

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(Presented at the meeting of November 12, 1945)

Introduction

A small cecidomyiid midge which frequently infests the flower buds of tomato has been known to exist in Hawaii since 1906 when Dr. O. H. Swezey (13)[2] of the Hawaiian Sugar Planters' Association Experiment Station reared adults from larvae infesting tomato buds. Until the present report, published literature, summarized below, listed at least four species of *Contarinia* as occurring in Hawaii. These were:

(1) *Contarinia sorghicola* (Coq.), the sorghum midge.
(2) *C. solani* (Rübs.), on tomato.
(3) *C. maculipennis* Felt, on hibiscus and pikake (*Jasminum sambac*).
(4) *C. lycopersici* Felt, on tomato, eggplant and pepper.

The distinctive sorghum midge is well known and has not been confused with other species in Hawaii. However, knowledge of the biological and taxonomic relationships of the flower-infesting *Contarinia* in Hawaii has been confused in the past. The purpose of this paper is to present evidence indicating that the tomato-infesting midge, which was referred to in the literature as *Contarinia solani* (Rübsaamen) in earlier years and as *C. lycopersici* Felt during recent years, is the same species found infesting hibiscus (and several other plants discussed later). The bud midge from hibiscus was described by Felt as *C. maculipennis*. Host and breeding records, which demonstrate that the blossom midge in Hawaii breeds in a singularly wide range of hosts, are summarized. These include more plant families than have been known for any other species of gall midge thus far reported.

Literature

In the first record of blossom midge from Hawaii, Swezey (13) listed the species under the name *Contarinia solani* (Rübsaamen). This name correctly applies to a species which had been reared

[1] Published with the approval of the Director, Hawaii Agricultural Experiment Station as Technical Paper No. *135*.

[2] Figures in parentheses refer to literature cited at the end of the article.

from the blossoms of *Solanum dulcamara* in Germany and was described by Rübsaamen (12) in 1891. Swezey's original note follows: *"Contarinia solani* was bred from tomato buds where the larvae fed upon the young ovary of the blossom causing the buds and blossoms to blight and eventually fall off. The larvae of this species also pupate in the ground."

In 1911 Felt (5) described as *C. lycopersici* a species which had been reared from tomato flowers at St. Vincent, West Indies. Felt stated that *lycopersici* is related to *solani* but is a distinct species.

Barnes (1) in 1932 recorded the presence of *C. lycopersici* in Trinidad, West Indies where it was found infesting the flowers of tomato.

Tucker (14) in 1935 reported that several tomato fields in Barbados, West Indies had been infested with a blossom midge which did considerable damage to the flowers. The species had not been identified, but Tucker suggested it was *C. lycopersici.* In 1937 Barnes (2) confirmed the presence of *lycopersici* in Barbados.

Barnes (2), who had not had the opportunity of examining the blossom midge of Hawaii, but had studied specimens of *lycopersici* from the West Indies, commented in 1937 on the reported occurrence of *C. solani* in Hawaii as follows: "I believe that this is an erroneous identification and that the midge in question must be *C. lycopersici* Felt which is closely allied to *C. solani* but is distinct. *C. lycopersici* was described from larvae doing exactly the same type of damage to tomato buds in St. Vincent, West Indies, as O. H. Swezey described was taking place on Oahu."

In 1938 Illingworth (11) called attention again to blossom drop of tomato in Hawaii due to infestations of blossom midge.

In 1941 Callan (4) summarized the known distribution of *C. lycopersici.* He listed Trinidad, St. Vincent, Barbados, Grenada, St. Lucia and Dominica in the West Indies, British Honduras in Central America, British Guiana in South America, and Hawaii. Callan's record for Hawaii was based upon the conclusion of Barnes, cited above, regarding the identity of the species in Hawaii. All collections reported by Callan and earlier writers were made from tomato blossoms.

On the basis of observations and collections by members of the University of Hawaii Agricultural Experiment Station, Holdaway (8) in 1944 listed blossom midge, under the name *C. lycopersici,* as a submajor pest of eggplant and pepper as well as of tomato in Hawaii. In 1945 blossom midge was again listed by Holdaway *et al* (9) as a potentially serious pest of tomato, eggplant and pepper in Hawaii.

In 1933 Felt (6) described, as *Contarinia maculipennis,* a midge which O. H. Swezey had reared from the buds of hibiscus in Hawaii.

Illingworth (10) in 1934 stated that he had received hibiscus buds infested with midge larvae from the island of Hawaii about 1928.

Fullaway (7) in 1934 reported breeding the "hibiscus bud midge" from buds of *Jasminum sambac* (pikake).

Evidence of the coidentity of midges infesting different host plants in Hawaii

In April 1944 the writer began an investigation of the ecology and life history of blossom midge in Hawaii. Among the first objectives of this study was the determination of the identity and host range of the midge occurring on tomato. This species was believed by Holdaway *et al* (8, 9) to be the same as that infesting pepper and eggplant. Examination of material in the collection of the University of Hawaii Agricultural Experiment Station revealed specimens reared from *Momordica charantia* (bitter melon) and from *Brassica chinensis* (white mustard) which appeared to be identical with those reared from tomato, eggplant and pepper. During the course of the investigation, similar midges were reared from *Solanum rantonnetii* Carr. (Paraguay nightshade) and *Solanum tuberosum* L. (potato) as well as from several species of *Lycopersicon*. These and other records are summarized later in this paper.

Until January 1945 bud midge from hibiscus and *Jasminum sambac* had not been seen by the writer. It had been assumed that this midge, described as *C. maculipennis* Felt, was distinct from the species infesting crop plants. A field observation provided the first hint of their coidentity.

On January 3, 1945 the writer encountered a blossom midge infestation in a field of tomatoes in the upper Kipapa region near Wahiawa, Oahu. The number of tomato plants and blossoms found infested with midge larvae diminished with increased distance from one corner of the field. At the edge of the field in this corner occurred a hibiscus bush 80 per cent of the buds of which were infested with midge larvae. The close proximity of the infested hibiscus to the portion of the tomato field in which the highest incidence of midge infestation occurred suggested that hibiscus had served as the source of infestation for tomato. Moreover, this circumstance also suggested that the midge described from hibiscus as *C. maculipennis* Felt was not a distinct species from the one commonly infesting tomatoes in Hawaii and provisionally called *lycopersici*.

Midge adults reared from tomato and hibiscus appeared identical to the writer. However, in order to obtain more conclusive evidence that only a single species was involved in the infestations found on plants of different families, the experiments described below were conducted and specimens from the various hosts were submitted to

Dr. H. F. Barnes[3] of the Rothamsted Experimental Station, England, for examination.

Midge adults that were reared from larvae infesting hibiscus in the field were caged January 18, 1945 on Bounty tomato plants growing in clay pots in the University of Hawaii greenhouse at Honolulu. Five days later, mature tomato flowers and unopened buds in varying stages of development were examined for the presence of midge larvae. Several buds and a few open blossoms were found to be infested. In addition, a few buds carried midge eggs alone or eggs and a few first instar larvae on the inner walls of the syngenesious androecium. Most of the infested buds were approaching maturity but had not yet opened. The larvae were transferred from the tomato buds to glass vials containing moist soil. They immediately entered the soil where they subsequently pupated. The first adults emerged 14 days after the larvae had entered the soil.

As a parallel experiment, midge adults reared from larvae infesting tomato buds and blossoms in the field were also caged on tomato plants in the greenhouse. They oviposited in the tomato buds and the duration of the life cycle coincided with that of the midges originally reared from hibiscus and later bred on tomato under cage conditions.

Uncaged tomato plants of the same size and variety as those used in the above experiments were maintained as controls. They were kept on the same bench with the test plants and remained free from infestation during the experiments.

On March 17, 1945 midge adults reared from larvae naturally infesting *Jasminum sambac* (pikake) were caged on two Bounty tomato plants,[4] to determine if they would breed on tomato. Seven days later 15 infested buds were removed from the caged test plants. A few buds carried eggs and very small larvae, but the majority of buds contained larvae which were mature or approaching maturity. These were transferred to pupation vials containing moist soil. The first adults emerged on the 13th day after the larvae had been transferred to the pupation vials.

The midges reared on tomato, as progeny of parents reared from hibiscus and pikake, appeared to the writer to be indistinguishable from specimens reared from naturally infested tomatoes. Their coidentity was confirmed by Dr. Barnes as discussed later in the paper.

After determining that midges reared from field infestations of hibiscus and *Jasminum sambac* would breed on tomato, the specimens involved in these experiments as well as material reared from

[3] Dr. Barnes is an eminent authority on the taxonomy of this difficult family and his interest in the problem is greatly appreciated.

[4] Pupation jars containing emerging adults and also larvae and pupae in various stages of maturity were placed inside the experimental cages. Therefore, adults emerged daily for several days after the initial introduction on March 17.

the following hosts were sent to Dr. Barnes for identification: tomato (*Lycopersicon esculentum*), eggplant (*Solanum melongena*), Paraguay nightshade (*Solanum rantonnetii*), garden pepper (*Capsicum frutescens*), white mustard (*Brassica chinensis*), bitter melon (*Momordica charantia*), hibiscus, and pikake (*Jasminum sambac*). Since sending these specimens to Dr. Barnes, blossom midge has also been reared from Irish potato (*Solanum tuberosum*).

Dr. Barnes compared the specimens from Hawaii with *C. lycopersici* bred from tomato in Trinidad and Barbados, West Indies, and also with *C. solani* reared in England. His analysis of the problem is summarized below. Quotations are from Dr. Barnes' letter to the writer dated October 1, 1945.

1. There is probably one species of *Contarinia* in Hawaii which will live on the host plants cited above.
2. Most of the specimens from the West Indies "agree better with Felt's original description of *lycopersici* than with his description of *maculipennis*." However, certain individuals from Trinidad resemble very closely the specimens from Hawaii.
3. All of the specimens from Hawaii, with the exception of those from white mustard which were too broken to permit satisfactory examination, agree more closely with Felt's *maculipennis* description than with his description of *lycopersici*. However, Dr. Barnes writes, "There is considerable variation in the accepted specific characters and a special study is needed of individuals reared under different conditions and on different plants."
4. There is considerable evidence suggesting that the midge in Hawaii is the same species as *C. lycopersici* which occurs on tomato in the British West Indies. "The weight of biological evidence would justify your sinking *maculipennis* as a synonym of *lycopersici*." Nevertheless, Barnes would prefer postponement of such action until experiments can be conducted in the British West Indies to determine if *lycopersici* in that region is also capable of breeding on the different plant hosts reported from Hawaii.

Host and collection records of blossom midge in Hawaii

The host range of this midge (probably *C. lycopersici*) is of unusual significance because it includes species in five different plant families. Gall midges in general have a very narrow host range. Barnes (3) in 1939 reported, "The only recorded instance of a gall midge living on plants belonging to two families is that of *Macrolabis corrugans* F. Lw. which is reported to live on certain Umbelliferous and Labiate species."

Blossom midge adults have been reared from larvae found infesting the flower buds of all the plants listed in table 1. In addition, with but a few exceptions, midges were reared to the adult stage to provide the records which are listed under each host.

Table 1. Host and Collection Records of Blossom Midge in Hawaii

Host Plant	Date	Locality*	Collector
SOLANACEAE			
Lycopersicon esculentum Mill. (tomato)	6-3-42	U. H., Manoa	F. G. Holdaway & T. Nishida
	6-24-42	U. H., Manoa	T. Nishida
	4-29-44	U. H., Manoa	D. D. Jensen
	5-3-44	U. H., Manoa	D. D. Jensen
	5-16-44	U. H., Manoa	D. D. Jensen
	6-20-44	Waialua	D. D. Jensen & T. Nishida
	12-4-44	Kipapa Airfield	D. D. Jensen
	1-3-45	Upper Kipapa	D. D. Jensen
	1-11-45	Koko Head	D. D. Jensen
	2-13-45	Poamoho	D. D. Jensen
	7-25-45	Poamoho	Reported by W. A. Frazier
L. peruvianum var. *dentatum* Dun.	5-1-44	U. H., Manoa	D. D. Jensen
L. peruvianum var. *humifusum* Mull.	5-1, 3-44	U. H., Manoa	D. D. Jensen
L. pimpinellifolium (Jusl.) Mill.	5-4, 6, 9-44	U. H., Manoa	D. D. Jensen
L. esculentum x *L. pimpinellifolium* (Jusl.) Mill.	5-1-44	U. H., Manoa	D. D. Jensen
L. esculentum x *L. hirsutum* Humb. & Bonpl.	5-3-44	U. H., Manoa	D. D. Jensen
L. (hirsutum x *esculentum)* x *peruvianum* (L.) Mill.	8-3-45	Poamoho	D. D. Jensen
Capsicum frutescens L. (pepper)	5-10-43	Kaimuki	E. Akamine
	6-4-43		
	7-23-43	Kaimuki	T. Nishida
	6-20-44	Waialua	D. D. Jensen & T. Nishida
	3-21-45	U. H., Manoa	D. D. Jensen
	4-17-45	U. H., Manoa	D. D. Jensen
	5-22-45	U. H., Manoa	D. D. Jensen
Solanum melongena L. (eggplant)	5-10-42	Kaimuki	E. Akamine
	6-7-42	Pauoa Valley	T. Nishida
	2-16-43	Haiku, Maui	J. Shigeta
	4-28-43	Manoa	T. Nishida
	8-15-42	U. H., Manoa	T. Nishida
	6-4-43	Kaimuki	E. Akamine
Solanum rantonnetti Carr. (Paraguay nightshade)	7-11, 26-44	Honolulu	T. Nishida
Solanum tuberosum L. (potato)	5-25-32	Waianae	O. H. Swezey
	5-15-45	Waipahu	D. D. Jensen

* All collections listed were made on Oahu unless otherwise indicated.

Table 1.—Continued

Host Plant	Date	Locality*	Collector
CUCURBITACEAE			
Momordica charantia L. (bitter melon)	2-16-43	Haiku, Maui	J. Shigeta
	3-2-45	Haiku, Maui	D. D. Jensen
	5-15-45	Waipahu	D. D. Jensen
MALVACEAE			
Hibiscus sp.	1-3-45	Upper Kipapa	D. D. Jensen
	1-26-45	Manoa	D. D. Jensen
	2-7, 16-45	Manoa	D. D. Jensen
OLEACEAE			
Jasminum sambac Soland. (pikake)	1-11-45	Kaimuki	D. D. Jensen
	3-2-45	Waihee, Maui	D. D. Jensen
	3-19-45	Waiau	D. D. Jensen
CRUCIFERAE			
Brassica chinensis L. (white mustard cabbage)	1-2-43	U. H., Manoa (greenhouse)	T. Nishida

* All collections listed were made on Oahu unless otherwise indicated.

Lycopersicon esculentum Mill. (tomato). Blossom midge infestations in common tomato have varied in severity in Hawaii from a fraction of 1 per cent to over 80 per cent of the mature buds sampled. These observations agree with those reported by Callan (4) from Trinidad where *Contarinia lycopersici* was found infesting from 1.1 per cent to 83 per cent of the tomato flowers examined.

Capsicum frutescens L. (garden pepper). In several instances practically 100 per cent of the flowers of peppers in small private garden plantings have been found infested with midge larvae.

Solanum melongena L. (eggplant). Eggplant may at times be subject to heavy infestation by blossom midge. However, tomato and pepper may be preferred hosts because, on several occasions, midge larvae have been found infesting these plants growing in close proximity to non-infested eggplants.

Solanum tuberosum L. (potato). Blossom midge has been reared from Irish potato blossoms on only two occasions. However, this paucity of records from potato may be due to factors other than host preference. Since an infestation in potato blossoms does not result in economic loss, as is the case with infestations of tomato, pepper and eggplant flowers, the presence of midge larvae in potato blossoms ordinarily would go unnoticed. Moreover, potatoes do not blossom profusely in Hawaii. Furthermore, much of the potato acreage in the Territory is not grown in close proximity to perennial hosts of midge which might serve as ready sources of infestation.

The specimens reared from potato have not yet been submitted to Dr. Barnes for determination. However, there is little doubt that they will prove to be the same species that breeds on the other host plants listed.

Solanum rantonnetii Carr. (Paraguay nightshade). This plant is very rare in Hawaii. It was not known to exist here until July 1944 when Mr. T. Nishida of the University of Hawaii Agricultural Experiment Station submitted a specimen to Miss Marie Neal of the Bishop Museum for identification. He found most of the blossoms heavily infested with pepper weevil larvae. A few buds were found to harbor small dipterous larvae which were called to the attention of the writer. They were reared to the adult stage and proved to be blossom midge.

Momordica charantia L. (bitter melon). Mr. Shigeta reported severe damage by midge larvae to bitter melon flowers. Infested blossoms failed to open and hence did not become pollinated. Although the writer found infested blossoms at Haiku, Maui and at Waipahu, Oahu the percentage infestation was extremely low.

Hibiscus sp. Although only a few infestations of midge on hibiscus have been recorded, it is apparent that at times most of the blossoms on a bush may be infested. Over 80 per cent of the buds on a single plant in the upper Kipapa district were found infested on January 3, 1945.

Jasminum sambac Soland. (pikake). Pikake, which produces a profusion of blossoms, is apparently an important host of the midge. Since it is a perennial plant, grown in commercial stands to produce flowers for the lei industry, it may prove to be one of the key host plants in maintaining a midge population throughout the year. Over 75 per cent of the living buds sampled were found infested in the January 11, 1945 collection reported above.

Brassica chinensis L. (white mustard cabbage). This plant has not yet been found infested in the field. The single record to date is based on an infestation which developed on plants grown in the greenhouse. A note accompanying the collection data stated that the midge larvae were "fairly abundant" and that they occurred also on tomato flowers.

Seasonal Occurrence and Abundance of Blossom Midge in Hawaii

It has not yet been possible to make a consistent and detailed investigation of the abundance and distribution of blossom midge during each month of the year. However, the collection records summarized above reveal that this species apparently breeds in some of the solanaceous crop plants throughout the year. Collec-

tions have been made from either tomato, pepper or eggplant during every month of the year except September, October and November. It is probable that a careful search will reveal infestation during these months as well.

Most of the infestations which have been reported as a result of midge damage have occurred during the spring and early summer months, particularly May and June. However, during a search for the midge at other seasons, extremely heavy infestations were found on hibiscus and *Jasminum sambac* in January.

Summary

1. Experiments are reported which demonstrate that the gall midge, *Contarinia maculipennis* Felt, which infests hibiscus in Hawaii, is the same species which breeds in tomato blossoms and was known in Hawaii under the names *Contarinia solani* (Rübsaamen) and *C. lycopersici* Felt. Midge adults reared from hibiscus and *Jasminum sambac* have been shown to breed on tomato where they complete a life cycle indistinguishable from that of specimens originating on tomato.

2. The biological evidence reported and a comparison of specimens from Hawaii with *lycopersici* from the British West Indies indicate the probability that the species occurring in Hawaii is also *lycopersici.* If such is the case, the name *maculipennis* is a synonym of *lycopersici.* However, in the West Indies *lycopersici* has been recorded only from tomato while the species in Hawaii is now known to breed in several unrelated plants. This fact makes it inadvisable at present to relegate the name *maculipennis* to synonymy, since the possibility exists that the midge in the West Indies is biologically distinct from the midge in Hawaii despite the apparent absence of consistent morphological differences.

3. In Hawaii blossom midge has been reared from the following host plants: SOLANACEAE: *Lycopersicon esculentum* (tomato), *L. pimpinellifolium, L. peruvianum, Capsicum frutescens* (garden pepper), *Solanum melongena* (eggplant), *Solanum tuberosum* (Irish potato), *Solanum rantonnetii* (Paraguay nightshade); CRUCIFERAE: *Brassica chinensis* (white mustard or pak choy); CUCURBITACEAE: *Momordica charantia* (bitter melon); MALVACEAE: Hibiscus; OLEACEAE: *Jasminum sambac* (pikake).

The wide host range of blossom midge in Hawaii, involving five different plant families, is unique among gall midges of the family Cecidomyiidae. Only one other species has been recorded from plants belonging to more than one family, and in this instance only two plant families are involved.

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Virus Diseases of Plants and Their Insect Vectors with Special Reference to Hawaii

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(Presidential address, delivered December 10, 1945)[1]

This subject will be divided into the following three general parts:

Part I. Principles of insect transmission of plant viruses.

Part II. Insect species occurring in Hawaii known to transmit plant viruses, with a list of viruses transmitted by each.

Part III. Plant virus diseases known or reported to occur in Hawaii with special reference to their transmission by insects.

Introduction

The entomological and pathological implications of the war are far-reaching and it will probably be several years before their full significance for Hawaii can be evaluated. However, the handwriting is already on the wall. Despite the vigilance of our quarantine inspectors and the cooperation of the Army and Navy it is already apparent that undesirable insect species which were previously absent from Hawaii are being introduced. The exact manner in which recent insect arrivals reached the Territory has not been determined. Until recent years most of them were brought by boat. However, the heavy plane traffic through Hawaii during and since the war provides a means of insect entry which is a more serious hazard than that attending the slower water craft.

Several immigrant species have been discovered in Hawaii during the past two years. Because of their conspicuousness and the rapidity with which they have become abundant, some of these can be considered very recent arrivals—possibly by plane.

Quarantine inspectors in Hawaii have intercepted a number of living insects in planes which arrived from the mainland or from other Pacific areas. Due to the short period of time required by modern planes to travel thousands of miles, even delicate forms, such as aphids and leafhoppers, which cannot survive many hours away from suitable hosts, may reach Hawaii alive. Most of these insects are killed by spraying before they can escape from the planes. It is probable, however, that during the early part of the war before treatment of military planes had become a well established practice, or as a result of crash landings or other emergencies,

[1] Because of the length of the paper, the actual address as delivered was confined to Part I and representative portions of Parts II and III.

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insects reached Hawaii by planes from which they escaped alive. Furthermore, the most rigid quarantine system that can be put into practical service cannot hope to intercept all insects which reach Hawaii. This service is, however, successful in reducing the introductions to a fraction of what they would be if no regulations were in effect.

This problem has a direct bearing on the subject I have chosen for discussion today, because the hazard of introducing new virus diseases by means of viruliferous insects, or of introducing more efficient vectors of viruses already established, is greatly increased by aircraft, particularly under conditions imposed by war.

This discussion will be confined primarily to the entomological aspects of virus problems. Furthermore I shall not undertake a treatment of all known plant viruses or their vectors but shall deal in particular with the viruses and vectors known to occur in Hawaii. In addition, certain viruses not known to occur in Hawaii will be considered briefly because of the bearing they have on the virus problems of the Territory.

A review of the literature on virus diseases and virus research in Hawaii reveals that although a considerable number of viruses occur here, most of them have received only passing notice. Those which have been investigated most extensively are: yellow spot of pineapple (spotted wilt of tomatoes), sugar cane mosaic, chlorotic streak of sugar cane, corn mosaic, and to a lesser extent papaya mosaic and *Commelina* mosaic. Other viruses occur on truck crops, banana, ornamental flowers and weed hosts. These received little attention in earlier years because the plants on which they occurred played a very minor role in the agricultural economy of the Territory, or the viruses were not known to cause serious damage to their host plants.

The increasing importance assumed by diversified crops in Hawaii has resulted in a greater awareness on the part of entomologists and pathologists of the importance of virus diseases on the respective crops. Furthermore, the number and importance of these problems are usually found to increase as the acreage which is devoted to the crops in question increases.

PART I. PRINCIPLES OF PLANT VIRUS TRANSMISSION BY INSECTS

Before discussing particular diseases and insect vectors which occur in Hawaii, the nature of viruses and some of the pertinent general principles and problems associated with the transmission of viruses by insects will be considered briefly.

I—*Nature of viruses.* The ultimate nature of viruses has been the subject of speculation for many years. Because they are known to multiply only in living cells, and because they exhibit other properties which are usually considered characteristic of living organ-

isms, the opinion was prevalent until recent years that viruses were living entities. The announcement by Stanley (218, 219)† in 1935 and 1936 that he had isolated what appeared to be pure tobacco mosaic virus, and that it was composed of a crystalline protein of high molecular weight, was therefore an important milestone in virus research. Stanley also demonstrated (220) that by chemical treatment, the structure of this protein, which was shown by Bawden and Pirie (10, 11) to be a nucleoprotein, could be altered with resultant loss of virus activity. Reversal of this process restored the original structure of the protein and virus activity was thereby regained. Other workers have confirmed Stanley's results and several other viruses have since been demonstrated to be nucleoproteins of chemical structure similar to but distinct from that of tobacco mosaic.

II—*Transmission of plant viruses.* All plant viruses can probably be transmitted to susceptible hosts by grafting, providing grafts can be established. A few are transmitted through the seed and many can be transmitted by mechanical inoculation. However, the most important manner in which viruses spread from plant to plant in nature is by means of their insect vectors. Although the majority of insect species which transmit plant viruses occur among the aphids and leafhoppers, several species in other groups have also been incriminated as vectors. Below is given a list of the arthropod groups which have been reported as containing vectors of plant viruses. The species names are given for the vectors in all groups except the aphids and leafhoppers which comprise an extended list.

ARTHROPOD VECTORS OF PLANT VIRUSES

(Exclusive of the major groups of vectors, i.e., Aphididae, Cicadellidae)

Note: Further confirmation is needed of the transmitting ability of species whose names are preceded by an asterisk.

Species	Virus	References
ACARINA		
Eriophyes ribis Nalepa	Black-currant reversion disease virus	4, 96
INSECTA		
Orthoptera		
Melanoplus spp.	Potato spindle tuber virus	82
COLEOPTERA		
Diabrotica vittata Fab.	Cucumber mosaic virus	51, 52
D. duodecimpunctata (Fab.)	Cucumber mosaic virus	122
D. soror Lec.	Cucumber mosaic virus	9
Leptinotarsa decimlineata Say (larvae)	Potato spindle tuber virus	122
LEPIDOPTERA		
Pieris rapae (Linn.)	Cabbage mosaic virus	121

† Figures in parentheses refer to literature cited at the end of the article.

Species	Virus	References
DIPTERA		
**Tipula paludosa* Meigen (larvae)	Potato spindle tuber virus	59
THYSANOPTERA		
Thripidae		
Thrips tabaci Lind.	Tomato spotted wilt virus	125, 187
Frankliniella nigripes (Girault)	Tomato spotted wilt virus in Australia	8, 201
F. schultzei (Trybom)	Tomato spotted wilt virus in S. Africa	148, 149
F. moultoni Hood	Tomato spotted wilt virus in N. America	76, 77, 78
F. paucispinosa Moulton	Tomato spotted wilt virus in S. America	65
HEMIPTERA		
Piesmidae		
Piesma quadrata Fieb.	Beet leaf curl (Kräuselkrankheit) virus	96
P. cinerea (Say)	Beet savoy virus	96
Miridae		
Lygus pratensis Linn.	Rape savoy virus	96
	Potato spindle tuber virus	82
	Potato mosaic virus	59
HOMOPTERA		
Coccidae		
**Pseudococcus maritimus* (Ehrhorn)	Bean mosaic virus	58
**P. citri* (Risso)	Tobacco mosaic virus	164
**Lecanium corni* Bouché	Vine mosaic virus	214
Aleyrodidae		
Bemisia gossypiperda Misra and Lamba	Cotton leaf curl virus	80
B. nigeriensis Corb.	Cassava mosaic virus	81
Psyllidae		
**Mesohomotoma tessmani* (Aulm.)	Cacao swollen shoot disease virus	189
Cercopidae		
Philaenus leucophthalmus (Linn.)	Peach yellows virus	130
Delphacidae		
Peregrinus maidis (Ashm.)	Corn mosaic virus	115
Perkinsiella saccharicida Kirk.	Sugar cane Fiji disease virus	150
P. vastatrix Breddin	Sugar cane Fiji disease virus	159

Insect Transmission of Viruses

Virus diseases fall into two general groups on the basis of the insect vector relationships involved. The factors which determine these various vector-virus relationships are of fundamental importance from the standpoint of the biological phenomena involved as well as because of their economic importance in the dissemination of virus diseases.

One type of transmission is that in which the vector is able to transmit the virus immediately or within a very short time after it first feeds on a diseased plant. Such viruses are usually not retained

by their vectors for more than a short time after the vectors feed on healthy or immune plants. Watson and Roberts (237) have called this the "non-persistent" type of virus.

The other general type, designated as "persistent" viruses, includes those which must undergo a latent or incubation period in their insect vectors before the latter are capable of infecting healthy plants. This period varies from less than an hour up to several weeks depending upon the vector and virus involved. Furthermore, the vectors of persistent viruses retain the ability to infect healthy plants during much or all of their subsequent life without the need of feeding again on a virus source.

Non-persistent viruses. Viruses of the non-persistent type have the following general characteristics:

1. They usually require no incubation period in the vector.
2. They are not long retained by the vectors after the latter leave a diseased plant.
3. They are usually transmissible by mechanical means.
4. There is usually a relatively low degree of specificity between the virus and its vectors, particularly with reference to the aphids. Most of these viruses can be transmitted by several species. There are no well authenticated cases of leafhoppers transmitting non-persistent viruses.

Most of the virus diseases known in Hawaii are of the non-persistent type. A few of this type are transmitted mechanically with such ease that much of the spread in the field may be traceable to contaminated tools, clothing or hands. Two of our most common virus diseases—tobacco or tomato mosaic and cucumber mosaic—are among those which can easily be transmitted mechanically. The former, however, is paradoxical in that it is very difficult to transmit by means of insects.

Because of this ease of transmission by mechanical means, the idea has become accepted by many people that insect transmission of non-persistent viruses is also a purely mechanical process resulting from contamination of the vector's mouthparts. Yellow dwarf of onions, which has been transmitted by more than 50 species of aphids, is usually cited as an example of mechanical transmission by sucking insects. Other viruses which have been placed in this group are those causing potato spindle tuber and common cucumber mosaic. These are included in this group because they are easily transmissible by juice inoculation and also because several chewing insects, in addition to a number of sucking species, have been listed as vectors. Mechanical transmission of viruses by insects probably occurs in some cases, but recent work indicates that transmission by most sucking insects may involve biological as well as mechanical factors. Cucumber mosaic is a case in point.

Studies by Watson and Roberts (*237*) in 1939 on transmission of cucumber mosaic, Hyoscyamus virus 3 and potato virus Y by means of aphids, produced some unusually noteworthy results on this subject. They tested the transmitting efficiency of *Myzus persicae* (Sulz.), *M. circumflexus* (Buck.) and *Macrosiphum solanifolii* (Ashm.) under various conditions. It was found that the efficiency of the vectors was greatly increased if they were prevented from feeding for a time just prior to being placed on the disease inoculum. The transmitting efficiency increased with increased fasting time up to 1 hour. This unusual effect was obtained, however, only if the time the aphids fed on the source of the virus was reduced to a short period immediately preceding transfer to the healthy test plants. A 2-minute feeding period on inoculum was found to be most satisfactory. The efficiency of previously starved aphids decreased as the time of feeding on the infected plants increased. If this time was extended to an hour there was no increase in efficiency over unstarved aphids. The explanation suggested by the authors for the results reported was that the viruses are inactivated by some substance, such as an enzyme, produced by the aphids during feeding. This substance, according to their hypothesis, is not produced, or at least not in effective quantities, while the aphids are fasting. Furthermore, for several minutes after feeding is resumed, the inactivating substance may not be produced in sufficient quantity to inactivate the virus being ingested. Hence, fasting and short feeding periods result in increased efficiency of virus transmission.

Watson and Roberts also found that the species of aphids varied in their efficiency as vectors despite the fact that during the short feeding periods reported, all three species fed in the same parenchyma tissue. In view of the varying efficiency of the species, while feeding in the same tissue under the same conditions, the authors concluded that aphid transmission in these instances involves a complex vector-virus relationship and that the viruses are not transmitted mechanically. *M. solanifolii* was the least efficient of the three species under consideration. This was explained on the basis of more inactivating substance being produced by this aphid. Kassanis (110, 111) obtained similar results with the same and other species of aphids in transmitting tobacco etch viruses. In these experiments, efficiency was greatest if the aphids were starved for 4 hours and then fed for 2 minutes on inoculum before being transferred to healthy test plants.

These experiments are in contrast to differential efficiency exhibited by the same species of aphids in transmitting potato leaf roll (55) where high efficiency was correlated with phloem feeding which required longer periods of feeding time on the inoculum.

As further evidence that loss of infectivity by aphids is not due to cleansing of the mouthparts during feeding, Watson and Roberts (238) demonstrated that individuals of *Myzus persicae* may infect

a succession of healthy plants if the aphids are first subjected to a fasting period followed by a 2-minute feeding on infected plants before transfer to the healthy test plants. In contrast to these results unstarved infective aphids are usually unable to infect a second healthy plant if they are allowed to feed on the first plant for several minutes. The aphids which fed discontinuously, inserted and removed their stylets from as many as 10 different healthy plants before losing infectivity. During the same time interval, unstarved infective aphids feeding continuously on a single healthy plant lost the ability to transmit the disease. Therefore, it seems highly improbable that such viruses are only mechanically transmitted and are lost by being rubbed off during insertion and withdrawal of the insect stylets through healthy plant tissue.

On the basis of these experiments Watson and Roberts concluded that the presence of the hypothecated inactivating substance is the primary difference between the so-called non-persistent viruses and those which persist in their vectors. However, this hypothesis does not provide an explanation for the incubation period of viruses of the persistent type in their insect vectors. Retention of the persistent type virus by the vector for indefinite periods might be explained by the absence of an inactivating substance, but in such a case some other fundamental process or mechanism must be responsible for the latent period of the virus in the vector before transmission is possible. Furthermore, the factors involved in this process may be more complex than those which permit indefinite retention of the virus. However, since viruses which require an incubation period in their vectors are also always retained by the vectors for indefinite periods of time, it is probable that the factors governing the two phenomena are the same or at least are intimately associated.

Viruses of the persistent type. Viruses of the persistent type usually have the following characteristics:

1. A latent or incubation period in the body of the insect vector. This is the period between the acquisition of the virus by the insect and the time when the insect becomes capable of infecting healthy plants with the virus.
2. After becoming viruliferous the insect vectors usually retain the virus for an extended period of time or for life without the need of again feeding on a diseased plant.
3. The vectors are usually phloem feeders and the viruses usually produce symptoms which are associated with phloem disturbances. However, some persistent viruses occur in both phloem and parenchyma.
4. Most persistent viruses are not sap transmissible.
5. There is a greater degree of specificity between the insect vector and the virus than occurs among the non-persistent viruses.

Incubation period in the vector. An incubation period of the virus apparently occurs in the insect vectors of all viruses of the persistent type. In Hawaii, this has been demonstrated to occur in *Peregrinus maidis* (39) in the transmission of corn mosaic and in *Thrips tabaci* (125) during transmission of yellow spot of pineapple (spotted wilt of tomato). Presumably the incubation period shown to exist in *Myzus persicae* in transmitting potato leaf roll (215) also obtains in Hawaii, although this has not been tested experimentally.

The nature of the incubation period of the virus in the vector has been a subject of considerable discussion for a number of years but as yet no unanimity of opinion has developed on the question. The principal theories suggested to explain this latent period are: (a) that the virus must multiply itself in the body of the vector in order to develop a concentration great enough to permit emission of an infective dose by the insect; (b) that the latent period is the time required for the virus to pass through the walls of the intestine, enter the blood and make its way into the salivary glands from which it is presumably injected into the plants during feeding; (c) that it is a period during which the virus is changed in some necessary manner before the vector can transmit it.

The second theory is difficult to test because of the complications encountered in trying to detect the presence of the virus in specific tissues or fluids of the insect vector. It has been accomplished with respect to some tissues in a few insects, but not in experiments which were designed to measure the rate of virus movement through the respective tissues. As yet there has been no way discovered to obtain concrete evidence on the last theory.

The theory regarding multiplication in the insect has been reviewed by Storey (222), Leach (122) and Bawden (9). In this paper it will be discussed but briefly, and some aspects which have not been considered previously will be mentioned.

There is persuasive evidence both for and against the idea that the latent period in insects is due primarily to multiplication of the virus to an infective threshold. When sufficient facts are available they may reveal that virus multiplication occurs in some species and not in others. We can be certain that the problem is not a simple one even in the case of an individual disease and its vector. Although the incubation period of a given virus in its vector is usually constant within general limits, there may be wide differences between individuals within the same species. One of the most extreme examples is that demonstrated by Carter (39) in relation to *Peregrinus maidis* and discussed more fully later in this paper. In this species the latent period varies from 4 to 29 days. If this period is based upon multiplication of the virus, it is apparent that the physiological differences occurring among individuals or genetic

lines within a species have a direct influence on the multiplication rate.

Kunkel (119) in 1937 demonstrated that if colonies of infective leafhoppers of *Macrosteles divisus* (Uhl.) were exposed to temperatures of 31 to 32° C. for 1 day or longer, they lost the ability to transmit aster yellows virus either permanently or temporarily. A 12-day exposure to this temperature resulted in permanent inactivation of the virus in the insect. However, "colonies treated from 1 to 11 days regained ability to transmit after periods varying from a few hours up to many days. The longer the colonies were heat-treated, the longer it took them to regain ability to transmit. Colonies in which virus was undergoing natural incubation were affected to a greater degree by heat treatments than colonies that were infective at time of treatment." These results were interpreted to mean that short treatments inactivated only part of the virus and transmitting ability was regained when the virus had again increased to an infective level. The 12-day treatment was assumed to have inactivated all of the virus in the insect. The more marked effect of heat treatment on colonies in which the virus was undergoing natural incubation was construed as evidence that the quantity of virus in these insects was lower at the time of treatment than in insects already infective when treated. Kunkel showed further (120) that this leafhopper can live and reproduce normally at temperatures higher than those which inactivated the virus. This fact, together with the demonstrated ability of leafhoppers to become infective a second time by feeding on a diseased plant after all the virus had once been inactivated in them by heat treatment, are cited as adequate evidence that the loss of transmitting ability due to heat treatment resulted from an effect on the virus itself and not on the insect.

Black (17) reported experiments which were presented as additional evidence that the aster yellows virus multiplies in its vector. His technique involved transmitting the virus mechanically from insect to insect, usually at 0° C. By this method he demonstrated that juice from viruliferous insects is infectious at dilutions as high as 1 : 1000 in 0.85 per cent NaCl solution. Furthermore, although the minimum incubation period in mechanically inoculated insects varied from 11 to 45 days, the insects usually remained infective until they died. Black also presented evidence indicating that the virus reached its highest concentration in the insects several days before the vectors could transmit the virus to asters. Moreover, the virus concentration in some instances appeared to decrease towards the end of the incubation period. It was therefore suggested that part of the incubation period may represent a period of multiplication of the virus while the remaining portion may be the time required for the virus to move from the centers of multiplication to a site in the insect from which it may be injected into the plant.

One of the strongest arguments cited as evidence of virus multiplication in the insect vector is based on Fukushi's work with *Nephotettix apicalis,* var. *cincticeps* Uhl., the vector of rice dwarf disease. This is the only known case of a virus being transmitted through the egg of the vector to its progeny. Fukushi (*72, 73, 74*) in 1933, 1935 and 1939 demonstrated that congenital transmission through the egg takes place only when the female parent carries the virus. Infective progeny resulted from crosses involving viruliferous females and non-viruliferous males but not when the reciprocal crosses were made. The virus was passed from insect to insect through the egg to the 7th generation without the insects in question feeding on disease inoculum.

The justification for interpreting the various experiments reported here in the manner indicated above has been questioned by some, notably Bawden (9). The work on several other insect vectors suggests that if virus multiplication occurs, the rate must vary or else it is not fast enough to maintain the original charge of the virus. Otherwise multiplication should maintain the virus at an infective level throughout the life of the insect. This does not happen in many instances, examples of which are discussed below.

Freitag (69) showed that the ability of *Eutettix tenellus* (Baker) to transmit curly top virus diminished with increased time after completion of the incubation period. During the latter part of their lives, many leafhoppers completely lost the ability to transmit the virus or transmitted more and more infrequently. However, if such leafhoppers were permitted a second feeding on inoculum, they again became viruliferous. These results suggested that loss of infectivity had been due to exhaustion of the virus supply in the insect. This fact was confirmed for *Eutettix tenellus* by Bennett and Wallace (14), for *Cicadulina mbila* (Naudé) by Storey (222) and for *Peregrinus maidis* by Carter (39). Freitag also found that the length of the original feeding period on the virus source had an effect on the duration in the insect of infective ability. Short exposure to inoculum tended to result in a shorter infective period for the insect. A feeding period of several hours or days on inoculum usually resulted in more prolonged infectivity. However, there appeared to be a limit beyond which further inoculum feeding produced no additional effect in prolonging virus retention.

Another objection to the idea of virus multiplication in the vector is, that although the length of feeding time on the diseased plant may determine to some degree how long the virus is retained by the vector, it has little effect on the duration of the incubation period itself. This may be as long in a vector which fed for several hours or days on a diseased plant as it is for the same species when fed but a fraction of this time on inoculum. If the latent period is primarily one during which the virus must multiply to an infective

level in the insect, there should be a direct relation between the initial quantity of the virus ingested by the insect and the duration of the latent period. However, such a relationship does not exist. Even Black's experiments involving high dilutions of virus, which were considered to be evidence of multiplication in the vector, show that the incubation period in leafhoppers inoculated with the juice from viruliferous insects was as long in those inoculated with undiluted juice as it was in those inoculated with dilutions of 10^{-1} and 10^{-2}.

Another aspect of the problem which has not been considered is that if the incubation period of persistent viruses is due to multiplication of the virus, the minimum infective dose of such viruses must be many times that which is effective in the case of non-persistent viruses. As discussed previously, many of the latter viruses are transmitted most readily if the vector is permitted only a short feeding period of 2 minutes on the diseased plant and is then transferred immediately to the test plant. In contrast to this, even though vectors of persistent viruses are permitted to feed for several hours or days on the virus source, during which time the amount of virus ingested must be considerable, they are nevertheless incapable of infecting a healthy plant until the usual incubation period has been run.

Furthermore, the fact that infective individual vectors of persistent viruses frequently do not infect all of the plants they feed on but fluctuate irregularly in their transmitting ability, suggests that factors other than virus multiplication must also be involved.

Storey (222) cited a circumstance regarding the multiplication hypothesis which is of interest. When the virus of maize streak was introduced directly into the body of *Cicadulina mbila*, this leafhopper became infective, but within 1 to 3 weeks thereafter it again became non-viruliferous. In contrast to this, leafhoppers which were permitted to feed for only 15 seconds on a diseased plant retained the virus for 9 weeks. The reason for this is not understood, but it does show that the virus is more effective if taken in by mouth than by inoculation into the body cavity. Storey also suggested that entry by the intestinal route may be a necessary condition of multiplication if such multiplication occurs.

Relation of Persistent Viruses to the Plant

Bennett (12) has pointed out that several viruses of the type referred to here as persistent, are rather closely restricted to the phloem. However, others such as maize streak and spotted wilt occur in both phloem and parenchyma. Most persistent viruses have also been found to be transmitted by insects which ordinarily feed in the phloem. Dykstra and Whitaker (55) correlated transmitting efficiency in aphid vectors with the tissues in which they fed. Those feeding habitually in the phloem were found to be efficient vectors of potato leaf roll.

Studies by Fife and Framptom (66) revealed the manner in which one insect, *Eutettix tenellus,* is guided to the phloem in which it must feed in order to acquire or transmit the virus of sugar beet curly top. The saliva of the leafhopper was found to be alkaline in reaction. The reaction of the parenchyma tissue of the sugar beet leaf petiole is acid, but there is a pH gradient toward the alkaline side as the phloem is approached. This gradient increases sharply in the cells of the bundle sheath and in the adjacent parenchyma cells. It reaches its highest point in the phloem where the pH is approximately the same as that of the leafhopper's saliva. It was inferred, therefore, that the acid reaction of the outer parenchyma is distasteful to the leafhopper and that the latter is guided to the alkaline phloem by the pH gradient described. This idea was supported by the feeding response of the leafhoppers on plants treated with a high concentration of carbon dioxide. This treatment upset the pH gradient in the petiole of the sugar beet with the result that the phloem was temporarily made more acid than some of the parenchyma. When *Eutettix* fed on plants of this type they reached the phloem in only 12 per cent of the trials, whereas in normal plants 56 per cent of the feeding trials terminated in the phloem.

The feeding habits of the sugar cane leafhopper, *Perkinsiella saccharicida,* and its role in transmitting Fiji disease of sugar cane present an unusual situation which is not yet fully understood. North and Barber (158) in 1935 reported that the nymphs of this insect usually feed in the phloem whereas the adults appear to be indifferent to the vascular bundles and feed in the mesophyll. Nymphs can easily be shown to acquire the virus but apparently adults do not. It is possible that the difference in feeding habits is responsible for the inability of the adults to obtain the virus. However, if this is true it will be a case in which the virus can be acquired by the vector only from the phloem but can be introduced into a healthy plant through the mesophyll as well as the phloem. This must follow because adult leafhoppers can transmit the virus provided they acquired it during their nymphal stage.

The fact that viruses of the persistent type are usually, but not always, restricted to the phloem or occur in the phloem in the greatest concentration, provides an explanation why such viruses are seldom found to be sap-transmissible. The insect vectors are equipped to introduce the virus into the phloem cells without causing the death of these or of the surrounding cells. However, the relatively crude methods of mechanically inoculating viruses which have been developed thus far make it exceedingly difficult to reach the phloem cells without causing severe disruption of the tissues penetrated. As a result, the virus fails to establish itself except in rare instances.

It is of interest in this connection that Storey (222) and Black (17) have been able to inoculate successfully the viruses of maize streak and aster yellows into their respective insect vectors by mechanical means, but that the same viruses cannot be transmitted from plant to plant mechanically. In the case of maize streak, the virus can be transferred mechanically to the vector from infective plant juice and also from the body juice and freshly expelled feces of viruliferous leafhoppers (222).

Some factors affecting virus transmission by insects.

One of the most intriguing problems relating to virus transmission by insects, concerns the factors which determine which insect species may serve as vectors and under what particular conditions. The problem is a complex one involving the relationships of the insect to both the virus and the plant and also the relationships of the virus to the plant. A few of the possible factors will be considered briefly.

1. Non-vector species of insects may be able to acquire a virus and retain it for extended periods of time but lack the ability to infect healthy plants. Bennett and Wallace (14) demonstrated the presence of curly top virus in non-vector species of aphids, leafhoppers, thrips and mites. When transferred to healthy plants the virus was retained by *Myzus persicae* for 14 days and by *Aceratagallia californica* (Bak.) for 21 days, yet they were unable to effect transmission. The authors concluded: "Since the virus retained its activity for several days in the bodies of the two species of insects named above and since both fed in the phloem, their inability to cause infection was not due to lack of active virus or to the tissue on which they fed, but evidently resulted from the presence of an effective barrier to virus passage in some part of the insect."

Such a barrier has been demonstrated by Storey (222) to occur in a genetic strain of *Cicadulina mbila,* the vector of maize streak virus. By selective breeding, Storey was able to produce a pure stock of leafhoppers all of the members of which could transmit the virus. Within the same species he bred another pure stock in which none of the insects could normally serve as vectors. The first stock was called the "active" race and the second the "inactive" race. When these pure races were crossed it was found that "activity" was dominant and was transmitted as a simple Mendelian character. The most significant contribution which emerged from this work was the knowledge that the barrier to activity in this species occurred in the intestinal wall of the leafhopper. Inactive individuals could be made active vectors if, after they had fed on a diseased plant, the stomach wall of the insects was punctured with a fine needle to permit some of the infective plant juice to enter the blood

in the body cavity. The same result could be obtained by injecting infective plant juice or extracts from infective insects directly into the body cavity of inactive individuals.

2. Insects may be capable of acquiring the virus during only one of the life stages. This is true of thrips and apparently is also true of *Perkinsiella saccharicida* in transmitting spotted wilt and Fiji diseases respectively. In both instances the virus apparently must be acquired before the adult stage is reached. However, infective nymphs develop into adults capable of transmitting the virus. The reason for this is not understood. It is possible that a change takes place in the permeability of the intestinal wall which prevents passage of the virus in adults. This possibility might be tested by applying the same technique Storey (222) used in making vectors of "inactive" *Cicadulina mbila*. In the case of the sugar cane leafhopper the reason may also be found in the different feeding habits of the nymphs and adults as discussed earlier.

3. The insect vector may be able to acquire the virus from one host plant but not from a related species which also carries the virus. This has been demonstrated to be the case in aphid transmission of tobacco mosaic virus from tomato but not from tobacco. The same species of aphids may however transmit other viruses to and from tobacco. Black (16) and others have proved that the juices of several insect vectors inhibit the infectivity of tobacco mosaic and several other viruses. As yet, however, it has not been demonstrated that failure of insects to transmit viruses is due to virus inactivation by the living insects, although the work of Watson and Roberts discussed earlier is very suggestive in this regard.

4. Another question which bears on the role of insects in transmitting virus diseases pertains to the manner in which an infective quantity of virus is introduced into the plant. It is common knowledge that many viruses can be transmitted at will by the use of a large number of vectors whereas tests involving individual insects often result in no transmission or in but a small percentage of positive cases.

Carsner and Lackey (33) and Severin (204) have advocated the "mass action" hypothesis. According to this idea, the increased percentage of transmission provided by groups of insects over individuals is partially due to the combined effect of several small, sub-infective doses of virus, any one of which alone would not have been sufficient to cause the disease. In contrast to this idea, Storey (222) and others hold that "a group will succeed if at least one of its members would have succeeded alone; if none would have succeeded alone, then the group will not succeed."

The same viruses and vectors were not used in arriving at these diametrically opposed hypotheses. The process by which several individually sub-infective virus injections attain infective concen-

tration in a plant has not yet been adequately explained. More work needs to be done on the subject. However, in passing, a report from Queensland is of particular interest in this regard despite the fact that experimental evidence from which the conclusions were drawn is not cited. The report of the director of the sugar experiment stations of Queensland for 1938 (194) contained a discussion of the susceptibility of certain cane varieties to Fiji disease. These varieties contain a certain amount of wild cane ancestry in their stock which provides desirable plant vigor and resistance to mosaic but confers high susceptibility to Fiji disease. The nature of the susceptibility is of unusual interest. "Whereas a stool of a resistant variety may require to be fed upon by say eight or ten infective insects [*Perkinsiella saccharicida*] before it will contract the disease, susceptible varieties may require only one insect per stool. When these insects are blown out of a diseased field by a high wind it is obvious that many stools will receive one hopper whereas very few would receive, say, five or six. Herein lies the danger of a susceptible variety in that it can become diseased when fed upon by a single infective insect."

If susceptibility and resistance of this type exists, it is strong evidence that the infective dose necessary to cause the disease varies with the variety of cane. Furthermore, the "mass action" hypothesis is necessary to account for infection by 5 to 10 leafhoppers on plants which fail to become infected when fed upon by but a single viruliferous leafhopper.

5. Two distinct viruses occurring together in a plant may be transmitted by a vector which is incapable of acquiring one of the component viruses when such occurs alone in a plant. Smith (216), during the past year, has reported that the rosette disease of tobacco is due to a complex consisting of two distinct viruses: vein-distorting virus and mottle virus. The vein-distorting virus cannot be transmitted mechanically but is transmitted by *Myzus persicae*. The mottle virus is easily transmitted mechanically but cannot be transmitted by *Myzus persicae* unless it occurs in the same plant which carries the vein-distorting virus. When this condition occurs the complex may be transmitted by the aphid at daily intervals for 20 days without again feeding on the virus source. Moreover, once the aphid has become infected with the virus complex, it may sometimes transmit only the mottle virus, at other times only the vein-distorting virus and sometimes the entire complex.

Origin of "new" virus diseases.

New virus diseases are being described each year in various parts of the world. Of interest to us here in Hawaii is the fact that less than a year ago a previously undescribed virus disease of papaya was discovered at Kailua, Oahu. This disease shows evidence of

becoming a serious threat to the papaya industry here if it continues to spread at its present rate. Whenever such a new virus appears on a commercial crop plant the question arises as to where it came from or how it originated. There are several possible answers but in the case of most new viruses the correct answer usually cannot be determined. Among the possible answers are the following:

1. The virus disease may have been introduced from some other part of the world where it had not been observed previously.
2. The virus may have been produced as a new disease for the first time in the host plant in which it is found. How this might take place has not been demonstrated. However, Johnson (104) in 1942 reported negative results from experiments he conducted to test a "viroplasm hypothesis." This postulates that extracts from healthy plants when inoculated into other healthy plants may result in some part of the protoplasm of the inoculum finding conditions compatible for growth and bring about an abnormality known as a virus disease in the host species.
3. The new virus may be a "mutant" strain of a virus already in existence, in which case the mutation may have altered the nature of the virus in relation to the host plant range, the insect vector or both. As evidence for this possibility, Jensen (102) published experimental results which he interpreted as evidence that yellow-mosaic viruses arise suddenly in plants infected with tobacco mosaic virus by some process similar to that of mutation.
4. The "new" virus may have existed previously in a different host plant, in which it may or may not have produced symptoms. It may have been confined to the original host or hosts for indefinite periods of time because, (a) a suitable vector was not previously available to transmit the virus out of the original host, or (b) though a vector was present which could transmit the virus among some hosts, no vector was previously present which was capable of disseminating the virus to susceptible hosts of economic importance.

Carter (36) has demonstrated that the operation of the situation described last is responsible for the freedom of pineapple from at least one virus to which it is definitely susceptible. This virus causes the common mosaic in *Commelina diffusa* (= *nudiflora* of Hawaiian authors[2]). He (36) showed that this virus is transmissible to young, tender pineapple plants by means of *Aphis gossypii* Glover, *Myzus persicae* and *Macrosiphum solanifolii*. Symptoms in pineapple closely resemble those produced by the yellow spot virus. Previous to Carter's work, pineapple had not been recorded as a

[2] The corrected identification of this common species of *Commelina* in Hawaii was provided by Dr. H. St. John of the University of Hawaii.

host for aphids. He found that the three species named would reproduce on very young seedlings but apparently are incapable of feeding satisfactorily on older pineapple plants. For this reason the virus is not likely to spread in the field. As pointed out by Carter, this demonstrates "that a plant may be highly susceptible to a virus but so unfavorable a host for a specific vector that natural infection is rare." It is probable that other viruses are also capable of causing serious injury to pineapple but lack vectors which can transmit them to this plant.

The only other insect-transmitted virus of pineapple is yellow spot, transmitted by *Thrips tabaci* (125). When yellow spot first appeared as a pineapple disease it was expected to be a major problem. However, as will be discussed more fully later, the disease is of minor importance because pineapple is not a preferred host of the vector.

Bennett (13) in 1944 reported a virus which needs only a suitable vector to make it a serious economic disease. This virus, named dodder latent mosaic (*Marmor secretum*), is symptomless and, until recently, was undetected in dodder, its normal host. It has now been shown by Bennett to induce a severe disease on cantaloupe, and a less severe disease on sugar beet, potato, celery, tomato and some other plants. The virus occurs naturally in dodder, *Cuscuta californica* Choisy, which grows on a desert shrub, *Eriogonum fasiculatum* Benth. in southern California. No symptoms are observable on dodder, but as this plant attaches itself to the crop plants listed, the virus is transmitted. It has been found to be juice transmissible, and, to a slight extent, is transmitted through the seed of *Cuscuta campestris*, one of three species of dodder which were shown to transmit it. No insect vector is known, but Bennett points out that with the introduction of an efficient vector, this virus might easily cause a serious disease on several cultivated plants.

PART II. INSECT SPECIES OCCURRING IN HAWAII KNOWN TO TRANSMIT PLANT VIRUSES, WITH A LIST OF VIRUSES TRANSMITTED BY EACH

Insect species occurring in Hawaii and which have been reported to transmit plant viruses in some part of the world are listed in table 1. Opposite the species names are given the number of different viruses or distinct virus strains which have been reported transmitted by the respective species. In table 2, the names of the different viruses transmitted by each species are given with references to the literature on which each entry was based. Future research will undoubtedly show some of these viruses and strains to be synonyms.

Table 1. Insect species occurring in Hawaii, known to transmit plant viruses, and the number of virus diseases transmitted by each.

Species	Virus Diseases Transmitted
1. *Aphis citricidus* (Kirk.)	1
2. *Aphis ferruginea-striata* Essig	4
3. *Aphis gossypii* Glover	16
4. *Aphis maidis* Fitch	3
5. *Aphis medicaginis* Koch	1
6. *Aphis middletonii* Thomas	4
7. *Aphis rumicis* Linn.	13
8. *Brevicoryne brassicae* (Linn.)	8
9. *Cavariella aegopodii* (Scopoli)[a]	5
10. *Macrosiphum rosae* (Linn.)	4
11. *Macrosiphum solanifolii* (Ashmead)	30
12. *Myzus circumflexus* (Buckton)	16
13. *Myzus convolvuli* (Kalt.)[b]	6
14. *Myzus persicae* (Sulzer)	53
15. *Pentalonia nigronervosa* Coq.	4
16. *Rhopalosiphum pseudobrassicae* (Davis)	6
17. *Toxoptera aurantii* (B. de Fonsc.)	2
18. *Peregrinus maidis* (Ashmead)	1
19. *Perkinsiella saccharicida* Kirk.	1
20. *Dracculacephala minerva* Ball	1
21. **Orthezia insignis* Doug.	1
22. **Pseudococcus citri* (Risso)	1
23. **Pseudococcus maritimus* (Ehrhorn)	1
24. *Thrips tabaci* Lind.	2
25. *Pieris rapae* (Linn.)	1

[a] This aphid has been listed in most literature as *Cavariella capreae* (Fab.).

[b] If *M. pseudosolani* (Theob.) is a synonym of *M. convolvuli* (see footnote **, p. 555), this species is reported to transmit 11 different virus diseases.

* Virus transmission has been recorded in the literature, however, in the light of more recent work it is doubtful if these species actually are capable of serving as virus vectors.

Table 2. Insect vectors occuring in Hawaii with a list of viruses transmitted by each species. The virus strains listed are based primarily on the classification proposed by Holmes (96).

Virus	References
Aphis citricidus (Kirk.)	
1. Pea mosaic virus	156
Aphis ferruginea-striata Essig	
1. Celery calico virus	205
2. Celery mosaic virus, western	206
3. Celery crinkle-leaf mosaic virus (strain of western celery mosaic virus)	70
4. Poison-hemlock ringspot virus	71

Virus	References
Aphis gossypii Glover	
1. Abacá mosaic virus	161
2. Bean mosaic virus	250
3. Cauliflower mosaic virus	215
4. Celery calico virus	205
5. Celery mosaic virus, western	206
6. Cowpea mosaic virus	142
7. Cucumber mosaic virus, typical strain	51, 52
8. Cucumber mosaic virus, lily mosaic strain	83, 96
9. Cucumber mosaic virus, lima bean mosaic strain	85
10. Cucumber mosaic virus, southern celery mosaic strain	53, 241
11. Lily mottle and tulip break virus group (*Marmor tulipae*, amended) Lily coarse mottle virus Tulip coarse break virus	28
12. Lily yellow-flat virus (= lily rosette virus)	163
13. Onion yellow dwarf virus	54
14. Pea mosaic virus	156
15. Ornithogalum mosaic virus	209
16. Poison-hemlock ringspot virus	71
Aphis maidis Fitch	
1. Cucumber mosaic virus, southern celery mosaic strain	241
2. Onion yellow-dwarf virus	54
3. Sugar cane mosaic virus	22, 84, 115
Aphis medicaginis Koch	
1. Bean mosaic virus	250
Aphis middletonii Thomas	
1. Cauliflower mosaic virus	215
2. Celery calico virus	205
3. Celery mosaic virus, western	206
4. Poison-hemlock ringspot virus	71
Aphis rumicis Linn.	
1. Bean mosaic virus	63, 250
2. Broad bean mild mosaic virus	248
3. Celery mosaic virus, western	206
Lupin sore-shin virus (= pea mosaic virus)	43
4. Narcissus mosaic virus	18, 19
5. Onion yellow-dwarf virus	54
6. Pea mosaic virus	44, 169
7. Poison-hemlock ringspot virus	71
8. Potato leaf roll virus	165
9. Soybean mosaic virus	9
10. Spinach yellows virus	49
11. Sugar beet mosaic virus	96, 215
12. Sugar beet yellows virus (= Beta virus 4)	215
13. White clover mosaic virus	215
Brevicoryne brassicae (Linn.)	
1. Bean mosaic virus	250
2. Cabbage mosaic virus	121
3. Cauliflower mosaic virus	228
4. Crucifer black ring virus (Probably the same as cabbage ring necrosis virus of Bawden 9)	231

Virus	References
5. Crucifer mosaic virus (= Brassica virus 4) (may be turnip mosaic virus)	215
6. Onion yellow-dwarf virus	54
7. Stock mosaic virus (mild and severe strains)	230
8. Turnip mosaic virus	229
Cavariella aegopodii (Scopoli)	
1. Carrot virus	224
2. Cauliflower mosaic virus	215
3. Celery mosaic virus, western	206
4. Pea mosaic virus	156
5. Poison-hemlock ringspot virus	71
Macrosiphum rosae (Linn.)	
1. Celery mosaic virus, western	206
2. Narcissus mosaic virus	19
3. Onion yellow-dwarf virus	54
4. Pea mosaic virus	156
Macrosiphum solanifolii (Ashmead)	
1. Bean mosaic virus (common)	63, 153, 186, 250
2. Bean mosaic virus (yellow) (= Phaseolus virus 2)	186
3. *Commelina diffusa* mosaic virus	36
4. Cowpea mosaic virus	142
5. Cucumber mosaic virus, typical strain	89, 90
6. Cucumber mosaic virus, southern celery mosaic strain	36
7. Cucumber mosaic virus, potato veinbanding strain (= potato virus "Y" = Solanum virus 2)	57, 113
8. Hyoscyamus virus III	237
9. Iris mosaic virus (probably the same as iris stripe, 9)	27
10. Lily latent virus	96
11. Lily coarse mottle virus (part of *Marmor tulipae* Holmes, amended)	28
12. Narcissus mosaic virus	18, 19
13. Ornithogalum mosaic virus	209
14. Passion fruit woodiness disease virus	154, 155
15. Pea mosaic virus	44, 156, 169
16. Pea enation mosaic virus	167, 170
17. Pepper mosaic virus of Puerto Rico	195
18. Potato mild mosaic virus (virus "A")	57
19. Potato "bigarrure" virus	233
20. Potato calico virus	188
21. Potato leaf roll virus	57, 105
22. Potato crinkle mosaic virus	57
23. Potato spindle tuber virus, typical strain	96
24. Potato spindle tuber virus, unmottled curly dwarf strain	96
Potato rugose mosaic (See No. 7 for insect-transmitted vein banding component of this virus complex)	
25. *Primula obconica* virus	210
26. Soybean mosaic virus	9
27. Sugar beet mosaic virus	92
28. Tobacco etch virus, severe strain	110
29. Tobacco mosaic virus from tomato	93
30. Tulip breaking viruses (color adding and color removing strains; part of *Marmor tulipae*, Holmes amended)	26, 28, 140, 141

Virus	References

Myzus circumflexus (Buckton)

1. Cauliflower mosaic virus 215
2. Celery calico virus 205
3. Celery mosaic virus, western 206
4. Celery crinkle-leaf mosaic virus (strain of western celery mosaic) 70
5. Cucumber mosaic virus, typical strain 89
6. Hyoscyamus virus III 237
7. Ornithogalum mosaic virus 209
8. Poison-hemlock ringspot virus 71
9. Potato mild mosaic virus (virus "A") 57
10. Potato veinbanding virus (= potato virus "Y") 57, 237
11. Potato crinkle mosaic virus 57
12. Potato leaf roll virus 57
13. Soybean mosaic virus 9
14. Tobacco etch virus, severe strain 110
15. Tobacco mosaic virus, typical strain 91
16. Tulip breaking virus 26

Myzus convolvuli (Kaltenbach)**

1. Celery calico virus 205
2. Celery mosaic virus, western 206
3. Celery crinkle-leaf mosaic virus (strain of western celery mosaic) 70
4. *Freesia mosaic virus 215
5. Narcissus mosaic virus 19
6. Poison-hemlock ringspot virus 71

M. pseudosolani (Theob.)**

1. Cucumber mosaic virus, typical strain 9, 89, 91
2. Potato leaf roll virus 59, 105, 152, 210, 212, 215
3. Soybean mosaic virus 9
4. Tobacco mosaic virus 89, 93
5. Tomato narrow leaf virus 42

Myzus persicae (Sulzer)

1. *Allium neapolitanum* mosaic virus 29
2. Bean mosaic virus 250
3. Cabbage mosaic virus 121
4. Cabbage ringspot virus (Brassica virus 1) 215
5. Cabbage ring necrosis virus 9
6. Carnation streak virus 107
7. Cauliflower mosaic virus 228
8. Celery calico virus 205
9. Celery mosaic virus, western 206
10. Celery crinkle-leaf mosaic virus (strain of western celery mosaic virus) 70
11. Cowpea mosaic virus 142
12. Crucifer black ring virus (may be a synonym of ring necrosis virus) 231

** Since according to Essig (60), *M. pseudosolani* (Theob.) is probably a synonym of *convolvuli*, the viruses transmitted by aphids under these names are listed under *convolvuli* but identified with the aphid names which appear in the literature. Essig (60) also indicates that *M. convolvuli* and *M. pseudosolani* may be synonyms of *M. solani* (Kalt.).

* Transmission doubtful or in need of confirmation.

Virus	References
13. Cucumber mosaic virus, typical strain	88, 89, 90, 96, 237
14. Cucumber mosaic virus, southern celery mosaic strain	36, 96
15. Cucumber mosaic virus, potato veinbanding strain (= potato virus "Y")	57, 96, 113
16. Cucumber mosaic virus, lima bean mosaic strain	85, 96
17. Dahlia mosaic virus	96
18. *Datura virus]	215
19. Garlic mosaic virus	29
20. Hyoscyamus virus III	237
21. Henbane (*Hyoscyamus niger* L.) virus	193
22. Iris mosaic virus (probably iris stripe virus of Bawden, 9)	27
23. Lettuce mosaic virus	3
24. Lily mottle virus group (part of *Marmor tulipae*, amended)	28
Lily coarse mottle virus	
Lily virulent coarse mottle virus	
Lily latent mosaic virus	
25. Lupin mosaic virus	156
Lupin sore-shin virus (= pea mosaic virus)	43
26. Onion yellow-dwarf virus	54
27. Ornithogalum mosaic virus	209
27a. Papaya ringspot virus (page 577)	
28. Passion fruit woodiness disease virus	154, 155
29. Pea enation mosaic virus	9
30. Pea mosaic virus	44, 156
30a. Peach mosaic virus***	
31. Pepper mosaic virus of Puerto Rico	195
32. Poison-hemlock ringspot virus	71
33. *Potato aucuba mosaic virus [probably]	96, 215
34. Potato "bigarrure" virus	233
35. Potato mild mosaic virus (= potato virus "A")	57
36. Potato crinkle mosaic virus	57
37. Potato tuber blotch virus (= potato virus "F" = Solanum virus 8)	9, 215
Potato rugose mosaic virus (See No. 15 for insect-transmitted vein banding component)	
38. Potato leaf rolling mosaic virus	57
39. Potato leaf roll virus	57, 105, 165, 215
40. Potato spindle tuber virus, typical strain	96
41. Potato spindle tuber virus, unmottled curly-dwarf strain	9, 96
42. Rape mosaic virus (may be turnip mosaic virus)	126
43. Soybean mosaic virus	9
44. Sugar beet mosaic virus	92
45. Sugar beet yellows virus	215
46. Stock mosaic virus (mild and severe strains)	230
47. Tobacco mosaic virus, typical strain	93, 96
48. Tobacco etch virus (mild and severe strains)	110
49. Tobacco rosette virus complex	93
Vein-distorting virus	
Mottle virus (only when combined with vein-distorting virus)	
50. Tulip breaking viruses 1 and 2 (color removing and color adding viruses, part of *Marmor tulipae*, amended)	26, 28, 140, 141
51. Turnip mosaic virus	229

* Transmission doubtful or in need of confirmation.

*** Daniels, L. B. 1945. The peach mosaic disease. Science 101:87-88.

Virus	References

Pentalonia nigronervosa Coquerel

1. Abacá bunchy top virus 160, 161
2. Banana bunchy top virus 128
3. *Banana mosaic virus [probably] 129
4. *Cucumber mosaic virus, southern celery mosaic strain 96

Rhopalosiphum pseudobrassicae (Davis)

1. Bean mosaic virus 250
2. Cauliflower mosaic virus 228
3. Celery mosaic virus, western 206
4. Onion yellow-dwarf virus 54
5. Pea mosaic virus 156
6. Stock mosaic virus (mild and severe strains) 230

Toxoptera aurantii (Boyer de Fonscolombe)

1. Citrus "little leaf" virus 215
2. Lemon ribbing virus 40

Peregrinus maidis (Ashmead)

1. Corn mosaic virus 39, 84, 115
2. Corn stripe virus (may be corn mosaic virus) 7, 217, 221

Perkinsiella saccharicida Kirkaldy

1. Sugar cane Fiji disease virus 150, 158

Draeculacephala minerva Ball

1. Pierce's vine disease virus 67

Pseudococcus citri (Risso)

1. *Tobacco mosaic virus 164

Pseudococcus maritimus (Ehrhorn)

1. *Bean mosaic virus [doubtful] 58

Orthezia insignis [Listed as *insignia*] Douglas

1. **Ephiphyllum truncatum* virus [doubtful] 20

Thrips tabaci Lind.

1. Spotted wilt virus causing:
   a. Tomato spotted wilt 76, 187, 200, 213
   b. Pineapple yellow spot 125, 200
   c. Pea streak 124, 246
   d. Cineraria streak 106
   e. Tomato tip blight 96, 146, 157
2. *Tomato mosaic virus [doubtful] 47

Pieris rapae (Linn.)

1. Cabbage mosaic virus 121

* Transmission doubtful or in need of confirmation.

PART III. PLANT VIRUS DISEASES KNOWN OR REPORTED TO OCCUR IN HAWAII WITH SPECIAL REFERENCE TO THEIR TRANSMISSION BY INSECTS

A list is presented of virus diseases which have been reported in the literature to occur in Hawaii. With a few exceptions no research work has been done in Hawaii on these viruses. Therefore experimental evidence is still lacking that the majority of the viruses reported from Hawaii are identical with viruses known by the same names in other parts of the world. Most of the work reviewed in this paper, on insect transmission of the diseases listed, was carried out in other regions. However, the majority of insect species recorded as vectors of these diseases occur in Hawaii. Furthermore, most of the diseases reported from Hawaii will probably prove to be identical with or related to diseases known by the same names in other areas. Knowledge regarding the identity of the vectors and of the factors which influence insect transmission of the diseases in question is therefore of fundamental importance to future studies undertaken in Hawaii.

Plant Virus Diseases Known or Reported to Occur in Hawaii

(Only those diseases indicated by an asterisk have been transmitted experimentally in Hawaii.)

	Name	Page
1.	Bamboo mosaic	600
2.	Banana mosaic	572
3.	Bean mosaic	581
4.	Canna mosaic	601
5.	*Commelina mosaic	571
6.	*Corn mosaic	559
7.	Crotalaria mosaic	585
8.	Crucifer mosaic	578
9.	Cucumber mosaic	567
10.	Dianella odorata Bl. mosaic	601
11.	Eggplant mosaic	587
12.	Hippeastrum mosaic	601
13.	Lettuce mosaic	581
14.	Lily mosaic	571
15.	*Papaya mosaic	577
16.	*Papaya ringspot	577
17.	Pea mosaic	583
18.	Peanut mosaic	586
19.	Peanut rosette	585
20.	Pepper mosaic	586
21.	*Pineapple yellow spot	594
22.	Potato crinkle mosaic	597
23.	Potato leaf roll	599
24.	Potato leaf rolling mosaic	598
25.	Potato mild mosaic	597
26.	Potato mottle	597
27.	Potato rugose mosaic	598
28.	Potato veinbanding disease	598
29.	Spinach blight	580
30.	Soybean mosiac	582
31.	*Sugar cane chlorotic streak	565
32.	*Sugar cane mosaic	562
33.	Tobacco mosaic	588
34.	Tomato aucuba (yellow) mosaic	591
35.	Tomato fern leaf	587
36.	Tomato mosaic	588
37.	Tomato mottle mosaic	590
38.	Tomato spot necrosis	591
39.	*Tomato spotted wilt	591
40.	Tomato tip blight	595
41.	Tomato streak	590
42.	Tomato vienbanding disease	591

Corn Mosaic

The virus disease known as maize mosaic or corn mosaic is very destructive to corn in Hawaii. If several crops are grown in close succession, as is frequently the case in Hawaii, the disease incidence becomes very high, sometimes involving over 50 per cent of the plants. This results from the development of a high population of infective leafhoppers many of which move to the new corn plantings.

Much of the pertinent work which has been done on the relation of insects to this disease has been carried out in Hawaii. However, both the disease and the relation of the vector, *Peregrinus maidis,* to the disease need further careful investigation.

The first published description of corn mosaic was that of Weston (245) in 1917. However, Kunkel (114) in 1921 stated that the presence of the disease and its destructive nature in Hawaii were recognized by Dr. H. L. Lyon as early as 1914. During the first ten years after corn mosaic was reported in the literature, the opinion prevailed generally that, because of the similarity of the symptoms, this disease would probably prove to be due to the same virus that caused sugar cane mosaic. The fact that sugar cane mosaic is transmissible to and from corn by means of *Aphis maidis,* was a complicating factor in clarifying the identity of the disease and its vector.

Under the name of corn mosaic, Brandes (23) in 1920, discussed a virus disease which occurred in sorghum and corn in Puerto Rico and the southern United States. He described the disease and reported experiments in which *Aphis maidis* transmitted it from mosaic sorghum to healthy corn and from infected corn to healthy corn. It is now obvious that he was dealing with sugar cane mosaic virus and not that of true corn mosaic.

Kunkel (115) in 1922 reported insect transmission of sugar cane mosaic and corn mosaic under the heading "Insect transmission of yellow stripe disease." He was the first to report transmission of corn mosaic by the corn leafhopper, *Peregrinus maidis.* His experiments indicated that the virus could be transmitted from corn to corn by *Peregrinus maidis* but could not be transmitted from corn to cane. Furthermore, he reported that the corn leafhopper failed to transmit the cane disease from cane to cane. The stripe disease in cane and mosaic of corn were at that time thought to be due to the same virus. It was not until 1927 that reports were published suggesting the distinct identity of the viruses, one of which caused mosaic or stripe symptoms in sugar cane, corn and other plants (and is transmitted by *Aphis maidis*) and the other (transmitted by *Peregrinus maidis*) which caused symptoms in corn but does not infect cane.

Kunkel (118) in 1927 reported that the corn leafhopper, *Peregrinus maidis,* occurring in North Carolina was unable to transmit

the virus of sugar cane mosaic of the United States to corn. He concluded, "this suggests that the destructive mosaic of corn prevalent in Hawaii is distinct from sugar cane mosaic and from the mosaic of corn occurring in Louisiana and other Southern States."

In the same year, Stahl (217) described a stripe disease of corn in Cuba and stated it was not identical with sugar cane mosaic. It was transmitted by *Peregrinus maidis*.

In 1928 Hadden (84), working on insect transmission of sugar cane mosaic in Hawaii reported: "Two insects have transmitted the disease: the corn aphis from various grasses to cane and other grasses; and the corn leafhopper, *Peregrinus maidis*, from corn to corn and in one case from corn to Striped Tip cane." Hadden considered it probable that the single case of disease transmission from corn to cane by *Peregrinus maidis* was an accident. Stahl's conclusion that corn mosaic and sugar cane mosaic were distinct was cited by Hadden who concluded: "Corn aphis may transmit one kind of mosaic. Corn leafhoppers may transmit a different kind of mosaic. Or both of these insects may transmit more than one kind of mosaic."

The identity and relationships of the corn viruses reported from different parts of the world have not been adequately established despite the fact that they have *Peregrinus maidis* as a common vector. Holmes (96) calls them all maize mosaic virus (*Marmor zeae*). However, Bawden (9) in 1943 listed corn mosaic and maize stripe as separate diseases.

The corn mosaic or corn stripe disease reported from parts of the world other than Hawaii may be summarized as follows:

1. *Cuba.* Stahl (217) in 1927 reported transmission of corn stripe disease by means of *Peregrinus maidis* but not by *Aphis maidis*.

2. *Trinidad, B.W.I.* Briton-Jones (30) in 1933 reported a severe stripe disease of corn in Trinidad. He considered this to be distinct from corn mosaic reported from Hawaii and other parts of the world except that reported by Stahl from Cuba. Later the same year Baker (7) transmitted this disease at Trinidad from maize to great millet by means of *Peregrinus maidis*. Briton-Jones (30) stated that the width of the stripes produced on diseased plants was dependent largely on the number of *Peregrinus maidis* which fed on the affected plants. "Those heavily infested with the insect develop broader stripes than those lightly attacked." This observation has not been reported by any other writer. Furthermore, the vector experiments reported in Briton-Jones' paper were inconclusive. The fertility and condition of the soil seemed to have more effect on symptom production in the plants than did the *Peregrinus maidis* which were caged on them, although some transmission by insects apparently occurred. The observation was also made by this author

that "*Peregrinus maidis* is very common on young maize until the tassel is produced when the insect leaves the plant." In Hawaii such a migration from the plant has not been observed, and the corn leafhopper may be found in large numbers on corn plants until after the mature plants are beginning to dry up.

3. *Puerto Rico.* White stripe disease of corn in Puerto Rico was described by Cook[5] in 1936 to correspond with the symptoms reported from Cuba and Trinidad.

4. *East Africa.* Storey (221) in 1932 reported the presence of a maize disease closely resembling maize streak. However, it was found to be transmitted by *Peregrinus maidis* and not by *Cicadulina mbila,* the vector of maize streak. He suggested the possibility that it might be identical with the stripe disease of Cuba.

Although transmission of one or more corn viruses by means of *Peregrinus maidis* has been reported by Kunkel (115) and Hadden (84) in Hawaii, Stahl (217) in Cuba, Baker (7) in Trinidad, and Storey (221) in Africa, no data on the incubation period of the virus and its retention in the insect were published until Carter's paper (39) appeared in 1941. His experiments demonstrated that the incubation period of the corn mosaic virus in *Peregrinus maidis* normally varies from 11 to 29 days. However, in some instances much shorter incubation periods occurred. Some were estimated as low as four days. In all cases this short incubation period occurred in insects which were genetically closely related. Carter cited the report by Storey (222), that the ability of *Cicadulina mbila* to transmit maize streak is controlled by genetic factors and suggested that the short incubation periods in *P. maidis* in a few genetically related individuals "may also be due to genetically controlled factors affecting permeability of the insect's tissues. If such a relationship could be conclusively proved, it would surely establish incubation period as a function of the physiology of the vector rather than of the virus." This is a direction in which important fundamental work could be done on a basic problem which is still unsolved.

Carter kept some leafhoppers on a diet of 2 per cent sucrose solution for seven days during part of the incubation period of the virus in the leafhopper. In these individuals the minimum incubation period was 13 days, thus demonstrating that the normal insect diet of juice from living plants is not essential for normal incubation of the virus in the vector.

Carter's work demonstrated that *P. maidis* can acquire the virus as nymphs or adults. The percentage of individuals which acquired and transmitted the virus in several different test groups varied from 9 to 57 per cent. Most individuals, but not all, which transmitted the disease, infected an unbroken series of several plants

[5] Cook, M. T. 1936. Phloem necrosis in the stripe disease of corn. Jour. Agr. Univ. Puerto Rico 20:685-688.

when transferred at 2-day intervals. Retention of the virus by the leafhoppers varied considerably. The maximum retention, as shown by transmission to a succession of healthy plants, was 48 days after feeding on the disease inoculum.

There is need for more extensive research on the role of *Peregrinus maidis* in disseminating corn mosaic. As yet it has not been determined how long a leafhopper must feed on a diseased plant before it can acquire the virus. It should also be determined whether the leafhopper must feed on certain portions of the leaves (such as areas showing the mottle symptom) in order to acquire the virus. In the experiments reported by Carter, the leafhoppers acquired the virus from leaf tissue. It would also be of interest to know if the vector can obtain the virus from stem tissue as well.

Carter (39) pointed out that some factor exists which complicates the acquisition of the virus by the vector and this is apparently responsible for the low percentage of individuals which become vectors under some conditions.

In view of the varying symptoms which have been observed on plants affected with corn mosaic and the fact that Wellman (242) transmitted southern celery mosaic virus to corn by means of *Aphis gossypii,* the possibility exists that this virus also may be found in corn plants diagnosed as being affected with corn mosaic virus. Wellman stated that corn plants so affected were stunted and in some other respects were remarkably similar to plants infected with Cuban corn stripe.

Sugar Cane Mosaic

Mosaic has been one of the most important diseases of sugar cane in the world because of its injury to the plant and because of its cosmopolitan distribution. The almost universal occurrence of one of its insect vectors, *Aphis maidis,* has undoubtedly been responsible in large measure for the greater economic importance of this disease from a world standpoint than some of the other virus diseases of cane whose vectors are more restricted in their distribution. Although mosaic was reported first from Java, Brandes and Matz (25) consider it probable that it originated in New Guinea which is part of the general region where sugar cane itself is believed to have originated.

In Hawaii, mosaic was first noted by Lyon in 1908. It was then called yellow stripe disease. Although extensive research was conducted in Hawaii between 1910-1914, the results were not published until 1921 (127). Since that time the disease has been under investigation in Hawaii as well as in other parts of the world.

Brandes (22) in 1920 was the first to report transmission of sugar cane mosaic by means of insects. He transmitted the disease with *Aphis maidis* from mosaic sorghum to healthy cane. In the same year he (23) transmitted mosaic from sorghum and corn to

healthy corn. He reported this as mosaic disease of corn, but in the light of our present knowledge concerning the vectors of sugar cane mosaic and corn mosaic it is apparent that the virus he worked with was that of sugar cane mosaic.

Before the separate identity of corn mosaic and sugar cane mosaic had been established, Kunkel (115) in 1922 reported experiments in Hawaii on the transmission of "yellow stripe disease" in which aphids and leafhoppers were used as the test insects and corn and cane as the test plants. Apparently the series of corn plants used as inoculum contained both cane mosaic and corn mosaic because Kunkel stated *"Aphis maidis* transferred from mosaic corn plants to healthy cane plants transmitted yellow stripe disease." And, "the corn leafhopper (*Peregrinus maidis*) transmitted corn mosaic from corn to corn, but failed to transmit it to cane from corn or from cane to cane."

In the same report Kunkel stated that the sugar cane aphid, *Aphis sacchari* Zehnt., and the sugar cane leafhopper, *Perkinsiella saccharicida,* failed to transmit the virus from diseased to healthy cane.

Hadden (84) in 1928 published the results of experiments conducted in Hawaii on the transmission of sugar cane mosaic by insects. He also reported observations on the ecology of *Aphis maidis* which was found to reproduce on 34 species of grasses. Both sugar cane mosaic and corn mosaic were treated in this study but they were spoken of as the same disease in some of the discussion. However, Stahl's (217) announcement, published in 1927, that corn stripe disease in Cuba was distinct from sugar cane mosaic was cited by Hadden who therefore concluded it was possible that the mosaics transmitted in Hawaii by *Aphis maidis* and by *Peregrinus maidis* might be due to distinct viruses. During the course of this investigation *Aphis sacchari, Perkinsiella saccharicida, Stictocephala festina* (Say), *Draeculacephala mollipes* (Say)[6] and *Tetranychus exsiccator* Zehnt. failed repeatedly to transmit sugar cane mosaic.

Ingram and Summers (99, 100, 101) in 1936, 1937 and 1938, announced the discovery of two additional aphid vectors of mosaic in the southern United States. These are *Hysteroneura setariae* (Thomas) and *Toxoptera graminum* (Rond.). The former species was found to be the most common aphid on cane between 1930 and 1937 and although a much less efficient vector than *Aphis maidis,* it apparently was responsible for much of the rapid spread of mosaic because *Aphis maidis* was scarce in most areas. *Toxoptera graminum* was not found as generally as *Aphis maidis* but was common in some fields.

Tate and Vandenberg (226) in 1939 described experiments which demonstrated that the aphid *Carolinaia cyperi* Ainslie transmitted mosaic in Puerto Rico. Of 192 plants exposed to viruliferous

[6] The species in question may have been *D. minerva.* See footnote, p. 471.

C. cyperi, 31.2 per cent became diseased. In similar experiments *Aphis maidis* infected 34.5 per cent of 200 test plants. *C. cyperi* was found to breed on nut grass, *Cyperus rotundus,* in and around the cane fields. According to St. John and Hosaka (196) this grass is common in some parts of Hawaii. Exploratory experiments with *Aphis rumicis, Macrosiphum rudbeckiae* (Fitch) and *Aphis nerii* B. de Fonsc. were also reported by Tate and Vandenberg. Nine experiments with each of the first two species were all negative, but a single plant out of four exposed to *A. nerii* developed mosaic symptoms. Although this cannot be considered a demonstration of transmission by *nerii* it does mark this species as one which should be tested more extensively.

Costa Lima (50) in 1926 reported the belief that *Thrips minuta* var. *puttemansi* Costa Lima was a vector of sugar cane mosaic in Brazil. However, this has not been demonstrated experimentally.

It has been well established that there are several different strains of sugar cane mosaic. Summers (225) reported four in Louisiana in 1934 and Martin (134) in 1939 stated that 10 strains or substrains are known to exist, some of which are more virulent than others. Cuttings with mosaic were sent from Hawaii to Washington, D.C. where their virulence was compared with that of other mosaic strains. The Hawaiian strain was found relatively difficult to transmit and when infection did occur the symptoms were considered mild. This is a fortunate circumstance for Hawaii. Although mosaic was once a serious cane disease in Hawaii, it is now considered to cause only minor losses. This has come about through the development of cane varieties which are resistant to the mosaic. However, the danger of mosaic again becoming a serious problem in Hawaii is always imminent. A cane variety resistant to one strain of mosaic is not necessarily resistant to all of the other strains. Mr. Martin, of the H.S.P.A. Experiment Station, has informed the writer[7] that the POJ-36 cane variety is highly resistant to the mosaic virus strain occurring in Hawaii, but it is not resistant to the common mosaic strain of Louisiana. Both strains are transmitted by *Aphis maidis.* It would be easily possible for infective aphids to reach Hawaii alive by means of fast planes and, if allowed to escape, they could introduce the more virulent mosaic strain into Hawaiian cane fields where further dissemination could be accomplished by the *Aphis maidis* already established here. The fact that cane varieties which are resistant to some of the other mosaic strains have been developed, does not mitigate the danger. Such resistant varieties may not prove to be as satisfactory under Hawaiian conditions as are those now in use or in the process of development in Hawaii. Furthermore, converting large areas over to new varieties within a short period of time, would involve difficult problems and serious monetary losses. Such a sudden change might be necessary in the

[7] Personal communication.

event a virulent strain of the virus became established here. The rigid quarantine imposed in Hawaii on sugar cane cuttings of newly imported varieties has played a major part in preventing the introduction of new insects and diseases of this crop.

In most regions where sugar cane mosaic occurs, it has been possible to transmit the different virus strains by means of *Aphis maidis*. However, Storey[8] in 1936 announced that in Natal he found a cane variety, "Agaul," which showed typical mild mosaic symptoms, and which was assumed to harbor the prevalent mosaic virus. Attempts to transfer mosaic from "Agaul" by mechanical means or by *Aphis maidis* were unsuccessful. Furthermore, he found that there was no dissemination of the disease in the field in East Africa and concluded, "Either this mosaic pattern is a varietal character—a highly improbable conjecture—or the Agaul virus is different from the common sugar cane virus. This Agaul variety was imported to Natal from India . . ." The history of mosaic in India contains many variable results, according to Storey, including, at times, failure of transmission by *Aphis maidis*.

Sugar Cane Chlorotic Streak

This disease was first noted in Java in 1928. In 1930 Martin (131) reported its occurrence on several cane varieties in Hawaii. He gave the disease the name chlorotic streak and this name has become generally accepted throughout the world. Martin (135) reported transmission of the disease by means of hypodermic needle inoculation in one experiment. Negative results were obtained in all other trials. The disease can be killed in cane cuttings by subjecting them to hot water treatment for 20 minutes at 52° C. (132).

Martin (133) stated that the cause of the disease had not been determined, but that in many ways it resembled the virus type of disease more than the fungus or bacterial type. Holmes (96) included it in his handbook of viruses. Abbott and Sass (2) in 1945 stated that the demonstrated fact of insect transmission "gives strong indication that it is caused by a virus."

Host plants other than sugar cane have not been demonstrated, but Martin (132) reported that symptoms similar to those of chlorotic streak were found to occur on Job's tears, *Coix lachryma-jobi*, and on elephant grass, *Pennisetum purpureum*, which are often found growing in close proximity to sugar cane.

Insect transmission. Martin (132, 133) in 1936 and 1938 reported that no positive results had been secured in Hawaii from experiments conducted to determine the identity of an insect vector of chlorotic streak. The following species were used in these experiments: the cane aphid, *Aphis sacchari;* the corn leaf aphid, *Aphis maidis;* the sugar cane leafhopper, *Perkinsiella saccharicida;* the

[8] Storey, H. H. 1936. Proc. Fifth Congr. Internatl. Soc. Sugar Cane Technol. (Brisbane) 1935: 108-116.

green sharpshooter, *Draeculacephala mollipes;* the pink sugar cane mealybug, *Trionymus sacchari* (Ckll.); the onion thrips, *Thrips tabaci;* and the sugar cane stalk mite, *Tarsonemus spinipes* Hirst.

In 1942 Abbott and Ingram (1) reported transmission of chlorotic streak by means of the leafhopper *Draeculacephala portola* Ball in the southern United States. They obtained transmission to only 25 out of 490 plants tested. These results indicate that *D. portola* is a relatively inefficient vector or else that the experimental transmission was complicated by a factor which has not yet been determined. These authors pointed out that the genus *Draeculacephala* has been reported in Hawaii, Puerto Rico, Colombia and Louisiana where chlorotic streak is reported to spread under natural conditions, but not in Java where the disease was first described.

Until recently *D. portola,* which feeds on sugar cane in the Gulf States, has been misidentified as *D. mollipes.* True *mollipes* presumably occurs primarily in the northeastern United States and is not a sugar cane pest in Florida or Louisiana (1).

Martin (133) stated that natural spread of the disease occurs in certain regions in Hawaii. In both Hawaii and Australia, the disease is most prevalent in localities where rainfall is heavy. In view of this record of field spread we can assume that a vector of the disease probably is at large in Hawaii.

The report by Abbott and Ingram on transmission of chlorotic streak by *D. portola* and the confusion which has existed regarding the identity of some species in this genus are pertinent to the situation here. Until recent years the "sharpshooter" in Hawaii, which sometimes occurs on sugar cane, was identified as *D. mollipes* (247). Recently[9] it has been announced that both *D. minerva* and *D. mollipes* occur here; *minerva* may be the more common of the two species. In view of the results obtained by Abbott and Ingram in Louisiana it is probable that insect transmission of chlorotic streak in Hawaii can be demonstrated by using the *Draeculacephala* species we have here, even though *D. portola* is not one of them. This premise is supported by the fact that phylogenetic relationships are known to exist among the vectors of several virus diseases. Frazier (67) in 1944 reported nine species of leafhopper vectors for Pierce's vine disease in California. All nine species occur in the Amblycephalinae, a subfamily in which every species (including *D. minerva*) thus far tested has proven to be a vector. At the same time, many species of leafhoppers in other subfamilies have been tested and not one has been found to transmit the grape disease. Similar vector-virus relationships occur within the genera *Cicadulina* and *Perkinsiella* which include vectors of maize streak disease and Fiji disease of sugar cane, respectively. The three known species of vectors of maize streak all occur within the genus *Cicadulina. Perkinsiella* includes two species which have

[9] See footnote, p. 471.

been shown to transmit Fiji disease. In addition, Mungomery and Bell (150) and Pemberton (185) have pointed out that a third species must be the vector in Fiji. Furthermore, others of the 21 species listed by Pemberton (185) as occurring in the genus are probably vectors in other localities.

In view of the low percentage of chlorotic streak transmission obtained by means of *D. portola* in Louisiana it is probable that long series of experiments would have to be run with the main suspect species before negative evidence could eliminate them from the suspect group.

Cucumber Mosaic

Two of the cucumber mosaic strains discussed below are known in the literature by several different names. They are:

1. Cucumber mosaic virus, typical strain, (*Marmor cucumeris* var. *vulgare* Holmes).
   Synonyms: Common cucumber mosaic virus, Cucumber virus 1; Cucumis virus 1; Spinach blight virus.
2. Cucumber mosaic virus, southern celery mosaic strain (*Marmor cucumeris* var. *commelinae* Holmes).
   Synonyms: Southern celery mosaic virus; Celery virus 1.

The properties of the cucumber mosaic virus occurring in Hawaii, and its symptoms on various hosts have not been studied. It has been assumed that we have the typical strain or common cucumber mosaic. This is probably true in view of the fact that we also have a spinach blight which agrees in general with the description of the spinach blight on the mainland known to be due to common cucumber mosaic. In addition we have in Hawaii "fern leaf" of tomato, a disease induced by common cucumber mosaic virus in tomato.

It is now apparent, however, that we have more than one variety or strain of cucumber mosaic virus in Hawaii. Although it has not been definitely proved, there is evidence that the southern celery mosaic strain of cucumber mosaic, or a related strain, occurs in Hawaii. This virus was studied by Doolittle and Wellman (53, 239, 240, 241, 242, 243, 244). It was responsible for severe losses in the celery growing areas of Florida and was found to spread to celery from *Commelina nudiflora* which grows around the fields as a weed. When first investigated, this disease was assumed to be common cucumber mosaic. However, Wellman (240) in 1934, after a comparison of the symptoms on various hosts with symptoms produced by other viruses, concluded that the virus infecting celery and *Commelina nudiflora* in Florida was distinct from the strain known as common cucumber mosaic. He gave it the name southern celery mosaic (Celery virus 1). Part of the evidence Wellman presented as a basis for his conclusions was the fact that southern celery mosaic was transmissible to watermelons which,

he stated, are immune to common cucumber mosaic virus. In addition, *Commelina nudiflora* has not been found susceptible to common cucumber mosaic whereas it is the most important weed host of southern celery mosaic. The differential susceptibility to strains of cucumber mosaic virus shown by watermelon and *Commelina* has a bearing on the identity of the virus strains occurring in Hawaii. Parris (175) in 1936 recorded mosaic on watermelon (*Citrullus vulgaris*) in Hawaii. If this mosaic was caused by one of the cucumber mosaic viruses, it is probably one more closely related to southern celery mosaic than to common cucumber mosaic in the light of Wellman's report (240) that watermelon is immune to the latter virus strain. The few records of watermelon mosaic referred to by Walker (234) in 1933 were listed as being due to cucumber mosaic without differentiation of strains. *Commelina nudiflora* has been found to be the main weed host of southern celery mosaic virus in Florida. What has been considered to be the same plant, *Commelina diffusa* Burm. (= *nudiflora* of Hawaiian authors), in Hawaii was observed by Kunkel (114) in 1921 and Hadden (84) in 1928 to carry a mosaic disease. In 1935 Carter (34) transmitted Commelina mosaic to pineapple by mechanical inoculation, and in 1937 he (36) transmitted it to pineapple by means of *Aphis gossypii, Myzus persicae,* and *Macrosiphum solanifolii.* Southern celery mosaic has been reported to be transmitted by the same species of aphids and in addition by *Aphis maidis.*

According to Price (192) the mosaic symptoms produced in the Hawaiian *Commelina diffusa* are similar to those produced by southern celery mosaic in *nudiflora* of Florida. He concluded that the viruses are probably related but that further proof is needed. In 1941 Price (192) reported the results of studies he conducted with a yellow strain and a green strain of mosaic in *Commelina diffusa* from Hawaii which he received through Dr. Carter. He found that these strains, though closely related, were not equal in their ability to infect dicotyledonous hosts when inoculated mechanically. Moreover, the symptoms produced on species of *Nicotiana, Cucumis sativus* L. and *Zinnia elegans* by the yellow and green strains of Hawaiian Commelina mosaic were similar to, but distinguishable from, those of both common cucumber mosaic and the southern celery mosaic strain of cucumber mosaic virus on the same hosts. Since the symptoms of Commelina mosaic in Hawaii were reported to vary from a brilliant yellow mottling to a mild green mottling, Price recommended referring to these strains as yellow and green variants of cucumber mosaic virus pending more comprehensive study of them under local Hawaiian conditions.

In view of the circumstances presented above, both the common cucumber mosaic virus (*Marmor cucumeris* var. *vulgare*) and the cucumber mosaic virus, southern celery-mosaic strain (*Marmor cucumeris* var. *commelinae*) will be treated in this paper.

Cucumber Mosaic Virus, Typical Strain
(*Marmor cucumeris* var. *vulgare*)

Synonyms: Cucumber virus 1; Cucumis virus 1; Common cucumber mosaic virus; Spinach blight virus; Tomato "fern leaf" virus; possibly also banana bunchy top virus.

Symptoms: This virus frequently causes yellowish green systemic mottling on cucumber. The plants become stunted, the leaves are small and may be curled or otherwise distorted. Fruits may also be mottled and misshapen (96). Parris (177) stated that the most dependable symptom is the bunching of the leaves at the tips of the vines.

Host plants. The host plant range of this virus is very wide. Holmes (96) listed 34 families of plants in which susceptible species occur. Thirty-two species are found in Cucurbitaceae alone. Among common cultivated plants listed by Holmes (96) as sometimes seriously affected are, cucumber, celery, spinach, tobacco, pepper and tomato. In spinach the cucumber mosaic virus causes "spinach blight" (see "Spinach blight") and in tomato it causes "fern leaf." Parris (177) listed the following plants in Hawaii as susceptible to cucumber mosaic virus: *Beta vulgaris* (beet), *Spinacea oleracea* (spinach), *Citrullus vulgaris* (watermelon), *Cucumis melo* (muskmelon), *C. sativus* (cucumber), *Cucurbita pepo* (pumpkin), *Nicandra physaloides* (apple of Peru), *Petunia hybrida* (petunia), *Solanum carolinense* (horsenettle), *S. nigrum* (nightshade) and *Viola* sp. (violet). On the basis of the list of susceptible hosts reported by Holmes, the group listed by Parris represents only a small portion of the number in Hawaii which should be susceptible hosts.

In addition to the diseases reported above caused by cucumber mosaic virus, Holmes (96) stated that this may also be the virus which causes bunchy top disease of bananas in Australia.

Insect transmission. Doolittle and Walker (51, 52) in 1920 and 1925 demonstrated transmission of this virus by means of *Diabrotica vittata, D. duodecimpunctata* and *Aphis gossypii.* Hoggan (88, 89, 90) in 1929 and 1930 transmitted cucumber mosaic virus by means of *Myzus persicae, Myzus pseudosolani* (*M. pseudosolani* probably = *M. convolvuli*), *Myzus circumflexus* and *Macrosiphum solanifolii.*

No studies have been reported on the transmission of common cucumber mosaic in Hawaii by means of insects. However, this is one of our most common virus diseases and it consistently takes a heavy toll of many plantings in Hawaii. Frequently the majority of cucumber plants in a field become infected before the crop has matured. Since the melon aphid, *Aphis gossypii,* is by far the most common aphid on cucurbits in Hawaii, it is probable that most of the spread in nature is due to this species. *A. gossypii* is also one

of our most common aphids on a large number of non-cucurbit host plants. It is thus able to maintain a relatively high population in nature during most of the year with the result that new plantings of cucurbits are seldom able to remain free from infestation for more than a short time.

There are varieties of cucumber which are resistant to cucumber mosaic, but their adaptability to Hawaiian conditions has not yet been adequately investigated and the varieties commonly planted here are susceptible to the disease.

Cucumber Mosaic Virus, Southern Celery Mosaic Strain
(*Marmor cucumeris* var. *commelinae*)

Synonyms: Celery virus 1, celery mosaic virus.

Host plants. Holmes (96) discussed the susceptible species as follows: "*Commelina nudiflora* L.; *Apium graveolens* L., celery; *Capsicum frutescens* L., pepper; *Musa cavendishii* Lamb and *M. sapientum* L., banana; *Zea mays* L., corn; and many other vegetables, grasses, and weeds, altogether 91 species in 23 families. So far as known, the host range of this strain and of the type strain are alike." Although the host range of this strain and the type strain are alike in general, the susceptible and insusceptible species tested are not the same for both strains as was demonstrated by Wellman (240) in 1934, and discussed earlier in this paper.

Disease symptoms. In *Commelina nudiflora,* celery and peppers the leaves become mottled and in the case of the latter two plants stunting and distortion of the plant occurs (96). In banana, the new leaves are stunted and often streaked with yellowish and green regions which frequently become necrotic. The stunted plants acquire a rosette-like appearance which in some respects resembles bunchy top of banana (241).

In corn, (*Zea mays*) Wellman (242) reported "the celery virus causes a stripe disease of maize in Florida very similar to but not identical with the white stripe of maize in Cuba. After numerous experiments it was evident that the celery-virus stripe on maize in Florida is transmitted by aphids but not by *Peregrinus maidis,* which Stahl (217) found was the vector of Cuban white stripe."

Mosaic diseases in banana and corn, in many respects resembling those reported above, occur in Hawaii and are discussed more fully under "Banana Mosaic" and "Corn Mosaic."

Insect transmission. Doolittle and Wellman (53) in 1934 reported transmission of southern celery mosaic by means of *Aphis gossypii.* In the same year Wellman (241) announced transmission of this virus to 2 banana plants by means of *Aphis maidis* and to 13 of 15 Lady Finger banana plants exposed to viruliferous *Aphis gossypii.* Although both test plants exposed to *Aphis maidis* contracted the disease, it would be desirable to test this aphid on a much longer series of plants in order to confirm its ability as a

vector of this virus and eliminate the possibility that transmission may have been due to the presence of more than one aphid species in the test population. This precaution is particularly appropriate for *Aphis maidis* because this species has not been found to be as versatile a vector of plant viruses as are some species of aphids. Only two other virus diseases (sugar cane mosaic and onion yellow dwarf) have been shown to be transmissible by *Aphis maidis*.

In addition to the aphid vectors of southern celery mosaic virus listed above, Carter (36) in 1937 reported he had received a personal communication from Wellman stating that *Myzus persicae* and *Macrosiphum solanifolii* are also vectors of this virus.

Holmes (96) listed *Pentalonia nigronervosa* as a vector of southern celery mosaic. This species has not been demonstrated to transmit the virus in the United States. Its inclusion by Holmes apparently results from the fact that southern celery mosaic was shown by Wellman (241) to be transmissible to banana in which it produced symptoms similar to bunchy top of banana, a disease known to be transmitted by *Pentalonia nigronervosa* in Australia. However, that these diseases are identical has not as yet been demonstrated.

Commelina Mosaic

The virus causing common mosaic in *Commelina diffusa* in Hawaii is a strain of cucumber mosaic. Carter (36) reported transmission of this virus to pineapple by means of *Aphis gossypii, Myzus persicae* and *Macrosiphum solanifolii*. (For a more complete discussion of Commelina mosaic see "Cucumber Mosaic," p. 567.)

Lily Mosaic

The only reference encountered in the literature to lily mosaic in Hawaii is one by Parris (175), who in 1936, listed a mosaic on *Lilium longiflorum*.

The identity, host and vector relationships are not known for the lily mosaic reported from Hawaii. Until recent years it was believed that the lily virus diseases (lily mosaic and yellow flat) were distinct from similar diseases occurring in tulips and some other plants. In 1935 Wellman (244) found lily to be among the plants susceptible to southern celery mosaic virus. Price (191) in 1937 found that leaves of zinnia plants infected with a strain of lily mosaic virus were immune from infection with cucumber mosaic virus. On the basis of these tests and the similarity of cucumber mosaic symptoms in lily to those of lily mosaic in lily, he concluded that lily mosaic virus should be classified in the cucumber mosaic virus group. The fact that *Aphis gossypii* was known to be vector of both lily mosaic (83) and southern celery mosaic (240) contributed to this conclusion. Another lily disease, known as yellow

flat, was considered by Price (191) to be due to a virus distinct from that causing lily mosaic.

In accordance with the conclusions of Price on the relationships of lily mosaic, Smith (215) placed lily mosaic under Cucumis virus 1. Holmes (96) in his classification of viruses erected the name cucumber mosaic virus, lily mosaic strain (*Marmor cucumeris* var. *lilii*) to include part of the lily mosaic complex of viruses.

McWhorter (143) in 1935 stated that the virus which causes "breaking" (color-adding and color-removing) in tulips is transmissible to lilies in which it produces a disease indistinguishable from lily mosaic.

Brierley and Smith (28) in 1944 reported the results of experiments in the United States on the properties, host range and vector relations of three lily mottle viruses, (which they assigned to the tulip virus group) as well as comparative data on tulip viruses 1 (color removing) and 2 (color adding) of McWhorter (144). Unfortunately the extensive investigations reported by Brierley and Smith do not include comparison of the viruses in question with the mosaic induced in lily by cucumber mosaic virus as reported by Price (191). Most of the host studies were in *Lilium*. They concluded that the five viruses studied (coarse mottle virus, virulent coarse mottle virus, latent virus, tulip virus 1 and tulip virus 2) might justify designation as separate virus entities. However, to avoid confusion in nomenclature they placed them all in *Marmor tulipae* of Holmes which must then be amended to include color-removing as well as color-adding virus. Brierley and Smith grouped them as three subspecies: tulip color-removing subspecies, tulip color-adding subspecies and lily mottle subspecies. As thus defined, *Marmor tulipae* was found by Brierley and Smith (28) to be transmissible by sap and by *Aphis gossypii, Macrosiphum solanifolii* and *Myzus persicae*. In addition *"Aphis fabae"*[10] was found to transmit the tulip color-adding and tulip color-removing strains. The previously reported additional vectors of these latter strains were *Anuraphis tulipae* (B. de Fonsc.) (141) *Macrosiphum solanifolii* and *Myzus persicae* (139, 140).

Banana Mosaic

In 1921 Kunkel (114) mentioned a mosaic on banana in Hawaii. No further reference to a banana virus here has been recorded in the literature. On October 3, 1945 the author noted what appeared to be virus symptoms of a mosaic type on the leaves of several young Chinese banana plants (*Musa cavendishii*) at Waipahu,

[10] The identity of the species in question is uncertain. Smith (215) in 1937 listed *Aphis fabae* Scop. as a synonym of *Aphis rumicis* Linn. Jones (109) in 1942 stated that *fabae* and *rumicis* are distinct species and can be distinguished easily on morphological grounds. He also concluded that in England *fabae* is a polyphagous species but that *rumicis* colonizes only on plants belonging to the genus *Rumex*. In a letter to the writer dated January 4, 1946, Professor E. O. Essig stated that the occurrence of *fabae* in the United States has not been definitely established.

Oahu. The oldest leaves appeared to be normal but the youngest four to six leaves were streaked with light and dark green areas in a linear pattern along the secondary veins of the lamina. As the leaves became older the symptoms appeared to become more conspicuous and there was a tendency for the chlorotic streaks to become necrotic. Marginal chlorosis occurred on some leaves to a slight extent. The diseased plants were stunted and the more mature affected leaves drooped to the ground.

Considerable variation occurred in the chlorotic and light green streaks which occurred on the leaves. The streaks on some leaves were narrow while on others larger portions of the lamina were light green to yellowish in color and appeared as a mottle or blotch or as irregular, longitudinal chlorotic areas. The light green streaks were usually not continuous, but were interspersed with areas of darker green tissue. Occasionally yellowish areas appeared diamond shaped on the lamina. Sometimes such areas had a green center and in other instances the entire affected area was yellow or light green.

On October 10, 1945, in company with Dr. F. G. Holdaway and Mr. J. W. Hendrix of the University of Hawaii, the writer found, on the Campbell banana plantation at Mokuleia, Oahu, a single half grown banana plant which exhibited mosaic symptoms such as described above. Symptoms occurred only on the two youngest leaves. There is some evidence that within the last two years Mr. Campbell removed a block of several hundred plants which were similarly affected. On October 14, 1945 the writer noted several young banana plants at Laie which showed streaking and chlorosis similar to that found at Waipahu. On October 23, 1945 Mr. J. W. Hendrix and the writer examined a 2-acre planting of bananas in Manoa Valley in which approximately 10 per cent of the plants showed mosaic symptoms. The symptoms were again found to vary considerably in their pattern, ranging from relatively mild mosaic symptoms of interspered light and dark green areas, to conspicuous elongate streaks and mottles which appeared to become necrotic on some of the older leaves. These streaks or chlorotic patches also occasionally appeared diamond shaped. Enough plants, both healthy and infected, were present to see the effects the disease may have on a commercial planting. Partial strangulation of the new leaves in the center of the pseudo-stem with resultant malformation of the leaves was noted in some plants. Most of the diseased plants were found to be stunted. Those which apparently became infected while very young had made practically no growth. Young suckers being produced from diseased stools were also diseased in most instances.

The writer visited this planting again November 25, 1945. Healthy plants had produced near-mature bunches of fruits, but

most of the diseased plants were still dwarfed and making little growth. During this visit it was noted that considerable mosaic-diseased *Commelina diffusa* was growing in the vicinity of the field. Furthermore the diamond shaped mosaic symptoms on many of the leaves of *Commelina* closely resembled the symptom pattern on some of the affected banana leaves.

In view of Kunkel's report of banana mosaic in 1921 and a report by Mr. Carpenter (quoted below) that a banana mosaic has been noted sporadically in the intervening years, it is probable that this disease ordinarily does not spread with great rapidity or regularity within banana plantings. However, it is possible that at times severe damage may have been produced in localized areas without being brought to the attention of the public.

The report by Wellman (241) of transmission in Florida of the southern celery mosaic strain of cucumber mosaic from *Commelina nudiflora* to banana by means of *Aphis gossypii* and *Aphis maidis* is of particular interest. The symptoms produced in banana by this virus included stunting of the leaves and of the plant as a whole, and chlorotic streaks on the leaves. In some instances the streaks became necrotic. The plants were reported to have acquired a rosette-like appearance which resembled bunchy top of bananas in Australia. The stunting of the plants and the streaking and necrosis of the leaves resemble symptoms observed on banana in Hawaii.

In this connection a report by Mr. C. W. Carpenter of the Pathology Department of the Hawaiian Sugar Planters' Association Experiment Station is very pertinent. In a letter dated October 23, 1945 addressed to the writer Mr. Carpenter stated: "A mosaic of the Chinese banana is not uncommon on Oahu; about 10 years ago the banana mosaic was very prevalent at Mokuleia after cucumbers were interplanted. The latter were seriously affected with mosaic."

The above reports by Wellman and Carpenter, when considered with the report by Price (192) that Hawaiian *Commelina* mosaic is very closely related to both common cucumber mosaic and southern celery mosaic, suggest the possibility that Hawaiian banana mosaic may be due to one or more strains of cucumber mosaic which occur in *Commelina,* cucumber, and probably other host plants in Hawaii.

Although the banana mosaic observed in Hawaii has not been demonstrated to be a virus, the symptoms strongly suggest that such is the case. Furthermore, similar symptoms in banana in other parts of the world have been shown by experimental transmission to be due to viruses. If mosaic in Hawaii proves to be a virus its identity and relationship to other similar viruses should be determined. The symptoms observed in Hawaii resemble in some respects several of the symptoms described for other virus-induced

banana diseases. These diseases (Banana heart-rot, infectious chlorosis, and bunchy top) will be discussed briefly although they are not known to occur in Hawaii.

Banana heart-rot or infectious chlorosis (due to Musa virus 3 of Smith). This disease has not been extensively studied. However, Magee (129) in 1930 reported its occurrence in New South Wales and thought it was transmitted by the banana aphid, *Pentalonia nigronervosa*. This disease causes yellowing and mottling of the foliage throughout the year and rotting of the heart leaf and central portion of the pseudo-stem during the winter. The rotting extends down into the corms and usually kills the plants. The yellowing symptoms are variable, but usually take the form of continuous or discontinuous streaks extending from the midrib to the margin of the leaf. These streaks vary in width from very narrow to more than ½ inch. The leaf symptoms resemble, in a general way, those found on diseased plants in Hawaii. A heart-rot stage in Hawaii has not yet been observed. This disease was not reported as being widespread in New South Wales, but Magee stated that if it were to become widespread it might be a greater threat to the banana industry than banana bunchy top.

Brazilian infectious chlorosis of banana. Wardlaw (236) in 1935 discussed a type of infectious chlorosis observed on banana in the state of Sao Paulo, Brazil. This he considered closely related to the banana heart-rot disease of Australia. The leaf symptoms were described as "light chlorotic linear areas extending as irregular, broken, sometimes anastomosing, lines or stripes from the midrib to the leaf margin." In contrast to the symptoms observed in Hawaii, the leaf mottle of the Brazilian disease tends to be masked on the older leaves. The disease has been shown to be systemic and is transmitted to the daughter suckers. This disease apparently does not injure the plant and diseased stools produce normal bunches year after year, except that mosaic mottling may occur on the fruit skin. No plants have been found in which rotting of the central leaf and the core of the pseudo-stem occurred as reported for the heart-rot disease in Australia.

The leaf symptoms of the disease in Brazil vary with environmental conditions. Mottling may fade noticeably or disappear completely from plants making rapid growth as a result of hot, wet weather or fertilizing. During the cold dry season when little growth takes place the leaf mottle develops maximum intensity.

Wardlaw (236) reported experiments in which the banana aphid *Pentalonia nigronervosa*, failed to transmit the disease.

A disease of bananas, believed by Wardlaw (236) to be the same as that reported from Brazil, has also been observed in Trinidad, West Indies, for several years. A similar disease of banana reported by Ogilvie (162) from Bermuda in 1928 is also believed by

Wardlaw (236) to be probably the same as the disease reported from Brazil. In Bermuda, however, the disease has a slight dwarfing effect on the plants.

Banana Bunchy Top

Magee (128) in 1927 reported that since its appearance in Australia in 1913 bunchy top disease has ruined the banana industry in several areas. It has also caused considerable damage in Fiji (where it is believed to have originated), and in Ceylon and Egypt (128).

The general symptoms of the disease are described by Magee (128). "The leaves of a badly infected plant are bunched together at the apex of the plant to form a rosette. Owing to the failure of the leaf stalks to elongate, the leaves stand more erect than normal. Infected plants are markedly stunted, there being little growth in height once the plant has taken the disease."

The first definite symptoms of the disease appear in the newly unfurled center leaf on which irregular, nodular, dark green streaks about 0.75 mm. wide appear along the secondary veins of the leaf lamina. Leaves produced subsequently may show whitish streaks along the secondary veins of the leaf blade before the leaf has unfurled. When these leaves unroll they bear dark green streaks along the secondary veins and dots or lines on the midrib and petiole. The leaves may also be somewhat stunted, slightly chlorotic, and the margins of the lamina may be wavy and rolled upwards slightly.

Due to strangulation or leaf congestion at the apex of the pseudostem, diseased plants often fail to throw the bunch or it may get partly out and be left standing erect or at right angles to the pseudo-stem. The fruit of such bunches is usually stunted.

Magee (128) transmitted this virus by means of the banana aphid, *Pentalonia nigronervosa*. Plants infected by means of this aphid developed primary symptoms in an average of 25 days.

Banana bunchy top virus was reported by Magee (128) to be transmissible to abacá or Manila hemp (*Musa textilis*) by means of *Pentalonia nigronervosa*. The symptoms reported by Magee in Manila hemp differ somewhat from those reported by Ocfemia for this disease in the Philippine Islands. Furthermore, the virus in the Philippines has not been found to be transmissible by *Pentalonia nigronervosa* from Manila hemp to banana. Of unusual interest is the report by Ocfemia and Buhay (160) in 1934 that in transmitting the virus from abacá to abacá in the Philippines, *Pentalonia nigronervosa* must feed on the inoculum for 12 hours in order to acquire the virus. In addition to this time the virus requires an incubation period of from 24 to 48 hours in the aphid vector before it can be transmitted to a healthy plant.

Papaya Mosaic

Parris (178, 182, 184) in 1939, 1940 and 1941 discussed a new disease of papaya which was discovered at Waialua and Lualualei, Oahu, in July 1937. In 1939 Parris (179) reported mechanical transmission of the disease to healthy plants in over 75 per cent of the tests conducted. He concluded that a virus was probably the causative agent. During the first 2 years after the discovery of the disease in Hawaii, papaya mosaic caused losses ranging from 6 to over 30 per cent in several large plantings (179). However, since 1939 diseased plants have been observed only occasionally.

Symptoms of the disease were described by Parris (179). Diseased plants are stunted and the foliage is yellowed. The petioles of diseased leaves are bent downwards at their point of attachment to the stem. "Linear, darker-green than normal, slightly raised, hydrotic-like streaks may be present on any portions of the main stem of a diseased plant, and on the petioles of yellowed leaves. . . . The streaks vary from ⅛ to 1 inch in length and from 1/32 to ⅜ inch in width. . . . Diseased leaves abscise rapidly, and 4 to 6 weeks after initial symptoms only a few badly distorted and undersized leaves remain clustered at the top. The leaves developed prior to symptom expression persist as a fringe around the base of the plant."

Parris also reported that "When a diseased papaya plant is decapitated or death of the growing point takes place naturally, new growth develops from the lower portions of the stem. It has been observed that the new shoots may all be healthy, or some be healthy and some diseased."

Holdaway and Look (95) in 1940 reported negative results from preliminary experiments conducted to determine an insect vector of papaya mosaic. The species tested included: *Aphis gossypii, A. medicaginis, A. maidis, Macrosiphum gei* (= *solanifolii*), *Myzus persicae, Empoasca solana* DeLong, *Nysius coenosulus* Stål, and *Thrips tabaci.*

Virus diseases of papaya have been reported from other parts of the world. Parris (178) considered it possible that the mosaic of Hawaii is identical with a disease in Queensland called "yellow crinkle" by Simmonds (208).

The mosaic of papaya in Hawaii is apparently distinct from the papaya mosaic reported from China by Ho and Li (87) in 1936.

Papaya Ringspot

Lindner *et al.* (123) in 1945 reported the presence in Hawaii of a previously undescribed papaya disease which appeared to be due to a virus. This disease, designated as papaya ringspot, was discovered by Dr. R. C. Lindner at Kailua, Oahu, in March 1945.

The disease is characterized by a mottle or mosaic pattern in the younger leaves resulting from irregular areas of leaf tissue

which are of a lighter green color than that of the rest of the leaf. The mosaic symptoms in the foliage are usually very conspicuous during the winter months, but mild during the summer. Diseased plants show retardation of growth and are weakened and killed more readily by adverse environmental conditions than are normal plants.

The most striking and reliable symptom of papaya ringspot disease appears in the fruits as they reach the ripening stage. Yellow rings with green centers are produced on the fruit surface. These rings vary in size from ⅛ to ¾ of an inch in diameter and may be circular or irregular in outline. The number of rings on a single fruit varies from a few to over 150.

Experiments conducted by the writer at Honolulu demonstrate that *Myzus persicae* is a vector of the ringspot virus. The disease was transmitted to 55 of 90 test plants exposed to viruliferous aphids between April 1 and July 31, 1945. After inoculation, symptoms developed in rapidly growing papayas in from 11 to 21 days.

Crucifer Virus Diseases

The relationships of some of the virus diseases which are found infecting cruciferous plants have not yet been adequately elucidated. Research work reported during recent years indicates that several viruses or virus strains are involved.

The identity, properties, host range and manner of dissemination of the virus diseases which occur in cruciferous plants in Hawaii are at present unknown. Kunkel (117) in 1924 was the first to report mosaic on Chinese cabbage, *Brassica pekinensis* (Lour.). Parris (177) in 1938 described the general types of symptoms which occur on some cruciferous plants here and cited the work done by Schultz (202) in 1921 as the source of his information on physical properties and manner of transmission. Parris (177) stated that mosaic had been seen in Hawaii on mustard, radish, Swiss chard, Chinese cabbage and turnip. In the same year he recorded (176) mosaic on daikon (*Rhaphanus* sp.) in Hawaii. Martin (138) in 1943 also reported mosaic on daikon in Hawaii. Frazier (68) reported mosaic as being among the most serious diseases of spoon cabbage and green mustard in Hawaii.

During recent years investigations have shown that several different virus diseases occur in cruciferous plants, and that most of these viruses have several plant hosts in common. The collective term, crucifer mosaic, therefore, loses meaning when the host range, symptoms, properties and methods of transmission are studied. Hoggan and Johnson (94) in 1935 described a crucifer virus transmissible by *Brevicoryne brassicae* and *Myzus persicae*. Tompkins (228) in 1937 described a mosaic disease of cauliflower which he considered distinct from the other diseases which had previously been reported from crucifers. He reported transmission by means

of the aphids *Brevicoryne brassicae, Rhopalosiphum pseudobrassicae* and *Myzus persicae*. "The host range included 51 vegetable varieties, 3 ornamentals and 5 weeds, all belonging to the family Cruciferae." In discussing Tompkins' cauliflower mosaic virus (Brassica virus 3 of Smith) Smith (215) in 1937 stated that Severin had informed him that this disease had been transmitted experimentally by the following aphids:

Species already occurring in Hawaii:

Brevicoryne brassicae—Cabbage aphid
Rhopalosiphum pseudobrassicae—False cabbage aphid
Myzus persicae—Green peach aphid
Myzus circumflexus—Lily aphid
Aphis gossypii—Melon aphid
Aphis middletonii—Erigeron root aphid
Cavariella aegopodii (= *capreae* Fab.)—Yellow willow aphid

Species not recorded from Hawaii:

Aphis graveolens Essig—Celery leaf aphid
Aphis apigraveolens Theob.—Celery aphid
Rhopalosiphum melliferum Hottes—Honeysuckle aphid

Tompkins (229) in 1938 described a mosaic of turnip and other plants which was readily transmitted by *Myzus persicae* and *Brevicoryne brassicae*. In the same year Tompkins and Thomas (232) described a mosaic disease of Chinese cabbage (*Brassica pe-tsai*) which was prevalent in central California. The host range of this virus included cauliflower, turnip, cabbage, radish, and mustard. The insect vectors were found to be the same as for turnip mosaic. In 1938 Tompkins, *et al.* (231) described a virus disease of cabbage and other crucifers which they named black ring. Again the vectors were shown to be *Myzus persicae* and *Brevicoryne brassicae*.

In 1939 Larson and Walker (121) described a destructive mosaic disease of cabbage in Wisconsin. All cruciferous plants tested were found to be susceptible to the disease. In addition, Swiss chard and spinach were among the noncruciferous hosts determined. The virus was found to be transmissible by juice inoculation. Three insects, *Myzus persicae, Brevicoryne brassicae* and the cabbage worm *Pieris rapae* were shown to be vectors of the virus. The discovery of the cabbage worm as a vector of a virus is of singular interest because it is one of the few records of a lepidopterous larva transmitting a plant virus. It was found necessary for the aphid vectors reported to feed on a diseased plant for ½ hour in order to acquire the virus. They were then capable of retaining the virus long enough to infect four different healthy plants consecutively without a second feeding on the inoculum. The feeding period on each successive test plant was 1 hour. It is of interest that this

virus can be transmitted by mechanical means and by a chewing insect and yet requires at least ½ hour of feeding by the aphid vectors in order to acquire the virus. Furthermore, once infective, the aphids retain the ability to infect four consecutive healthy plants over a period of 4 hours.

Although the relationships of the crucifer viruses reported above need further clarification, the evidence is increasing that several different but related viruses occur in these plants. Tompkins and Thomas (232) stated in 1938 that on the basis of symptoms, Chinese cabbage mosaic, cauliflower mosaic and turnip mosaic can easily be differentiated on Chinese cabbage, winter colma cabbage and purple top white globe turnip.

Walker, *et al.* (235) and Pound, *et al.* (127) in 1945 showed that a strain of turnip virus 1 of Hoggan and Johnson (94) and a strain of cauliflower virus 1 of Tompkins (228) may occur together in cabbage with the characteristic symptoms of each being apparent and varying in intensity as the air temperatures vary. Turnip virus and cabbage black ring virus symptoms were found to increase in intensity with increasing air temperature. This was in contrast to the cauliflower virus group in which symptom severity increased as the air temperature was decreased. When a strain of turnip virus or a strain of black ring virus occurred in cabbage together with a strain of the cauliflower virus "the resulting disease reaction was more severe than that produced by either virus alone."

The need for research on crucifer viruses in Hawaii is obvious. At least one of these viruses occurs here and very possibly there are more than one. Most of the known insect vectors of crucifer viruses have already become established in the Territory. This fact increases the hazard which accompanies the inevitable introduction into Hawaii of other viruses not already established here.

Spinach Blight

Parris (177) in 1938 reported blight as a virus disease of spinach in Hawaii. Symptoms were described as including mosaic, mottling, yellowing and distortion of the leaves and stunting of the plant. The disease was reported by Parris to cause severe losses in Hawaii occasionally.

Although several viruses have been reported to induce disease symptoms in spinach, blight is usually considered to be due to cucumber mosaic virus. Hoggan (92) in 1933 discussed the symptoms produced in spinach by cucumber mosaic virus, sugar beet mosaic virus and tobacco ringspot virus. Hoggan's paper also reported transmission of cucumber mosaic virus to spinach by means of *Myzus persicae* and *Macrosiphum solanifolii.*

Parris cited Hoggan's paper as a reference but listed *Aphis rumicis* as a vector in addition to the two species recorded by Hoggan. The writer has failed to find any other report in the literature

of *Aphis rumicis* as a vector of spinach blight. The report by Parris may have been based upon the fact that Hoggan had transmitted sugar beet mosaic virus to spinach. *Aphis rumicis* is a vector of sugar beet mosaic but was not used in the transmission experiments reported by Hoggan. According to Hoggan, the symptoms of sugar beet mosaic in spinach are distinct from those produced by cucumber mosaic.

Lettuce Mosaic

Parris (177) in 1938 reported that a lettuce mosaic occurred in a high percentage of plantings in Hawaii and resulted in considerable loss. Symptoms of the disease reported from Hawaii include yellowish discoloration and a mosaic pattern of the leaves, rugosity of the leaf blade, and stunting of the plants. Mosaic prevents heading in head lettuce varieties.

Holmes (96) listed the following plant species as susceptible to lettuce mosaic virus (*Marmor lactucae*): Compositae—*Senecio vulgaris* L., groundsel; *Sonchus asper* Hoffm., prickly sow-thistle. Leguminosae—*Lathyrus odoratus* L., sweet pea, *Pisum sativum* L., pea.

Transmission. Ainsworth and Ogilvie (3) in 1939 reported that experiments conducted in England resulted in lettuce mosaic transmission by *Myzus persicae* to 15 out of 33 plants and by *Macrosiphum solanifolii* to 1 out of 23 plants. The latter species was reported as being the most common lettuce aphid in southwestern England. The virus has also been shown to be juice transmissible and in addition is one of the viruses that is carried through the seed of diseased plants.

No insect transmission studies have been reported from Hawaii.

Bean Mosaic

A bean mosaic virus (*Marmor phaseoli* of Holmes) has been shown to be transmissible to several species of *Phaseolus*, to *Vicia faba* L., *V. lathyroides* L. and *Lespedeza striata* Hook. and Arn. (79), all within the family Leguminosae. It is not transmissible to garden pea or sweet pea.

The symptoms of bean mosaic virus vary considerably depending on age and variety of the host and on environmental conditions. Holmes (79) states "first leaves to be affected are crinkled, stiff, chlorotic; later leaves show chlorotic mottling; leaf margins often rolled down."

This disease seriously reduces the yield of beans in many bean-growing areas. An unidentified bean mosaic occurs in Hawaii. Parris (177) discussed it briefly and its presence in Hawaii has also been noted by Martin (136, 137) in 1941 and 1942. According to a personal communication from members of the Departments of Vegetable Crops and Pathology, University of Hawaii Agricultural

Experiment Station, bean mosaic is of moderately common occurrence in Hawaii, but usually does not cause serious crop losses.

Insect vectors. The first record of bean mosaic transmission by means of insects was reported in 1922 by Nelson (153) who found that the potato aphid, *Macrosiphum solanifolii,* served as a vector. He failed to transmit the virus by means of *Empoasca fabae* (Harris). Elmer (58) in 1925 believed the mealy bug, *Pseudococcus maritimus,* was a vector, but this has not been well established although Fajardo (63) in 1930 reported transmission of bean mosaic by means of an undetermined species of mealy bug in addition to *Aphis rumicis, Myzus persicae* and *Macrosiphum solanifolii.* In 1936 Zaumeyer and Kearns (250) reported studies conducted in Colorado where they obtained transmission with 10 of 11 species of aphids tested and failed to transmit the virus by means of 10 species of insects other than aphids. The aphids found to transmit bean mosaic were: *Aphis gossypii, Aphis medicaginis, Aphis rumicis, Brevicoryne brassicae, Rhopalosiphum pseudobrassicae, Myzus persicae, Macrosiphum solanifolii, M. pisi* (Kalt.), *Aphis spiraecola* Patch, *Hyalopterus atriplicis* (Linn.) and *Macrosiphum ambrosiae* (Thomas). The first six species listed are known to occur in Hawaii at the present time.

The aphid which failed to transmit bean mosaic was *Neothomasia populicola* (Thos.) collected from poplar. With the exception of *Aphis medicaginis,* which infected 44 per cent of the plants on which it was tested, all of the demonstrated aphid vectors transmitted the disease to over 50 per cent of the test plants. *Rhopalosiphum pseudobrassicae* infected 100 per cent of the test plants upon which it fed.

Soybean Mosaic

Martin (136, 138) in 1941 and 1943 reported the occurrence of a soybean mosaic at Kailua and Waipio, Oahu. These are the only records of this disease in Hawaii and its identity is not known. A soybean mosaic was encountered in Indiana in 1920 (75). It was described as severely stunting and distorting the plants. The petioles and internodes were shortened, the leaflets were small, misshapen and puckered with dark green puffy areas along the veins. The pods were stunted, flattened and more sharply curved than normal. Diseased plants remained green longer in the season suggesting delayed maturity. The virus was transmitted mechanically and by seed but no insects were tested as vectors. The disease was confined largely to the side of a field near a planting of garden beans which were affected with a mosaic disease. This suggests the possibility that it may have been a bean virus which spread to soybean in this instance.

Smith (215) reported that soybean is susceptible to pea enation mosaic virus (= Pisum virus 1). The symptoms were described as

"a mottled dark and light green mosaic pattern." Zaumeyer (249) in 1938 listed soybean as a susceptible host of a pea streak virus which was carried by *Macrosiphum pisi*. However, the disease symptoms on soybean were not described.

Pea Mosaic

The exact identity of the pea mosaic which occurs in Hawaii has not been established, since no transmission experiments involving the disease have been reported from Hawaii. Parris (177) listed pea mosaic in Hawaii. His description of some of the mottle symptoms produced on garden pea (*Pisum sativum*) and sweet pea (*Lathyrus odoratus*) are characteristic of common pea mosaic virus (*Marmor leguminosarum* Holmes = Pisum virus 2 of Smith). However, the reference (166) cited by Parris regarding the vector applies to a distinct virus known as pea enation mosaic virus (*Marmor pisi* Holmes).

In addition to the two pea viruses mentioned above, there have been at least three mosaic diseases of pea described as new in recent years (249), and several virus-induced pea streaks (46, 249). Furthermore, pea is a susceptible host for several other virus diseases which were described originally from other plant species (especially in the Leguminosae) in which they are more commonly encountered in nature (124, 246, 251).

Chamberlain (44) in 1936 cited literature to the vectors of pea mosaic. According to this author the following vectors have been determined: *Macrosiphum pisi* (227), *Aphis rumicis* and *Rhopalosiphum viciae* (possibly = *A. rumicis*) (21), *R. fabae* (145), *Myzus persicae* (98) and *Macrosiphum solanifolii* (168). In New Zealand Chamberlain (44) transmitted a pea mosaic to several hosts by means of *Myzus persicae, Macrosiphum solanifolii,* and *Aphis rumicis.*

Osborn (169) in 1937 reported transmission of pea virus 2 (= pea mosaic virus, *Marmor leguminosarum* Holmes) by both nymphs and adults of *Macrosiphum pisi, M. solanifolii* and *Aphis rumicis.* Transmission was obtained by means of individual aphids as well as with larger numbers. These insects were shown to be able to acquire the virus during a feeding period of 5 minutes on diseased plants and were able to transmit the virus to healthy plants during a 5 minute period immediately following removal from the inoculum. None of the colonies retained the virus for more than 1 hour when fed continuously on a healthy plant. However, Osborn states, "when held without access to food, the bean aphid was shown to retain the virus for 5 hours, the pea aphid for 8 hours, and the potato aphid in one instance for 24 hours."

Pea Enation Mosaic Virus (*Marmor pisi* Holmes)

It is not known definitely that pea enation mosaic disease occurs

in Hawaii. However, since some of the early symptoms on some varieties may be confused with those produced by common pea mosaic, it is possible that the enation disease occurs here. In view of this fact and because of the unusual insect vector-virus relationships involved, this disease will be discussed briefly. In addition to chlorotic mottling, this virus sometimes produces necrotic spots and enations on the lower surface of the leaves. Holmes (96) states that the pods become distorted and, in broad bean, striping as well as chlorotic spotting may occur on the leaves. Transmission experiments could easily yield information as to which virus occurs in Hawaii if there is only one, since pea enation mosaic virus produces symptoms on the pea varieties Perfection and Horal which are resistant to common pea mosaic, *Marmor leguminosarum* (96).

Bawden (9) lists *Myzus persicae* as a vector of pea enation mosaic virus but does not cite a reference to the publication which reported this aphid as a vector of the virus in question.

Osborn (166, 167, 168) demonstrated that pea enation mosaic virus is transmitted by the pea aphid, *Macrosiphum pisi,* and the potato aphid, *M. solanifolii,* but not by *Aphis rumicis.* Both aphid species were unable to infect healthy plants until after a period of virus incubation in the vectors. The duration of this period varied considerably, but averaged about 12 hours for both species. In two colonies of the pea aphid, held at 80° to 90° F., the incubation period of the virus in the aphids was not less than 4 nor more than 10 hours. At the other extreme, one of the colonies held on plants in a greenhouse in which the temperature varied from 64° to 70° F. showed an incubation period of not less than 72 nor more than 96 hours.

Both the pea aphid and the potato aphid were shown to retain the virus for extended periods of time after becoming infected. Infective colonies of pea aphids, when transferred daily to a succession of healthy plants, retained the virus for 29 days. Single aphids were shown to retain the virus for 23 days. Potato aphids that acquired the virus from diseased broad bean, *Vicia faba,* retained the virus for as long as 21 days while feeding continuously on insusceptible tomato plants.

Since practically all viruses transmitted by aphids require no incubation period in the vector or but a very brief one, and since such viruses are lost by their vectors soon after feeding on healthy plants, the definite and sometimes extended incubation period of pea enation virus in the pea and potato aphids, and the ability of these aphids to retain the virus for long periods of time, is of great interest. A large number of aphid species have not been tested as possible vectors of this disease. However, in view of the vector-virus relationship demonstrated, it is probable that the number of species capable of transmitting this virus will be small.

Crotalaria Mosaic

Illingworth (97) in 1931 noted in a pineapple field in Hawaii, Crotalaria plants which showed marked mosaic and yellowing symptoms. "Leaf mosaic" of Crotalaria was listed by Martin (136) in 1941 from Kohala, Hawaii. The writer has observed a conspicuous mosaic on the same plant at Kailua, Oahu during 1945.

The identity of the Crotalaria mosaic in Hawaii is not known.

Johnson and Lefebvre (103) in 1938 reported a mosaic disease which appeared in the Crotalaria nursery at Arlington, Virginia. It was described as "a disease characterized by a general stunting of the plants, by mottling, blistering, and malformation of the leaves, and by abnormally stimulated lateral branching or witch's brooming." This virus was transmitted by juice inoculation to broad bean, *Vicia faba*. No transmission by insects was reported. These authors refer to a report published in 1927 indicating that a witch's broom disease of Crotalaria was found in Java which was considered to be of a virus nature and assumed to be spread by insects.

It is possible that Crotalaria mosaic virus is a strain of one of the cucumber, bean or pea viruses which include several legumes among their susceptible host species.

Peanut Rosette

Nothing is known of peanut rosette in Hawaii except that such a disease occurs here. Martin (136, 137) listed it as occurring at Kailua, Oahu in 1941 and in several places on Oahu in 1942.

Holmes (96) classified a peanut rosette virus as *Marmor arachidis*.

Storey and Bottomley (223) in 1928 reported that rosette is a destructive disease of peanuts in South Africa and that a similar disease occurs in tropical Africa, Java and India. It was reported to be transmissible by grafting but not through the seed or by mechanical inoculation. The plant may be severely altered by the virus due to chlorosis, stunting and malformation of the leaflets. Sometimes the entire plant may appear as a tuft of small curled leaves. The first evidence of infection was described by Smith (215) as a faint mottling of the youngest leaves. Plants showing distinct mosaic symptoms usually are not severely stunted.

Three distinct graft-transmissible strains of the virus were reported by Hayes (86) to exist in the Gambia. Chlorosis rosette caused the young leaves to be flaccid and develop yellow patches which later appeared as a light green mottle. Green rosette produced no chlorosis and the leaves were darker in color than normal. Rosette type No. 3 did not affect the normal color of the leaves but caused them to be smaller and thicker than normal. The stems were much thickened and each branch curved in a clockwise direction. Smith (215) considers it possible that Hayes' chlorosis rosette and green rosette may be due to two distinct viruses since both may

be put in the same plant without exhibiting any cross immunity. Hayes' report also indicated that the presence of weeds or close spacing of the plants resulted in less spread of rosette. The reason for this effect was not determined but it was suggested that with increased vegetative ground cover there was less evaporation from the soil resulting in more dew formation which may have affected the habits of the insect vector or the physiology of the plant.

Insect transmission of rosette was accomplished by means of *Aphis laburni* Kalt. (= *A. leguminosae* Theob.) in South Africa, but 13 species of leafhoppers failed to transmit the disease (221, 223).

Since the disease is reported to be non-transmissible through the seed or by juice inoculations, and since the only demonstrated vector, *Aphis laburni,* is not known to occur in Hawaii, it is probable that additional species are capable of transmitting the virus. In Hawaii *Aphis medicaginis* and *A. rumicis* would be logical suspects.

Peanut Mosaic

Martin (136) in 1941 recorded peanut mosaic from Kailua, Oahu where peanut rosette was also noted. No peanut mosaic has been reported in the literature as a distinct disease. However, Smith (215) pointed out that the first symptoms of rosette consist of a leaf mottle. Furthermore, some plants exhibit a pronounced mosaic pattern in the leaves and only a limited amount of stunting. In view of these circumstances it is possible that the mosaic of peanut recorded by Martin was caused by the peanut rosette virus complex. Nevertheless, it may also be that a mosaic-inducing virus exists which is distinct from the rosette virus. Diseases which are characterized by great diversity of symptoms in the same host plant frequently prove to be due to a complex of related or unrelated virus strains which may be transmitted in varying proportions at different times and under different conditions.

Pepper Mosaic

Parris (146) in 1941 and Martin (136, 137, 138) in 1941, 1942 and 1943 reported mosaic on pepper in Hawaii. Although pepper mosaic in the Territory has received only occasional and brief notation in the literature, it is a very common disease. During the past two years the writer has seen several plantings on Oahu in which approximately 50 per cent of the plants were infected.

The viruses responsible for pepper mosaic in Hawaii and their insect vectors have not been determined. This disease is usually attributed to tobacco mosaic virus which, according to Holmes (96), causes "yellowish primary lesions followed by systemic chlorotic mottling." Cucumber mosaic virus, southern celery mosaic strain, also causes symptoms in pepper which are described by

Holmes (96) as "mild mottling and grayish discoloration of leaves, malformation of fruit, stunting of plant." Symptoms of both general types have been observed in Hawaii.

Eggplant Mosaic

In 1942 Martin (137) reported "common mosaic" on eggplant at Ewa, Oahu. I have been informed by members of the Vegetable Crops Department of the University of Hawaii Agricultural Experiment Station that a mosaic on eggplant has been noted on Oahu on several occasions during recent years. The identity of this disease is not known. Eggplant (*Solanum melongena*) has been used in relatively few virus studies. Harter (85) in 1938 reported it susceptible to cucumber mosaic virus, lima-bean mosaic strain (*Marmor cucumeris* var. *phaseoli* of Holmes). This virus strain is transmitted by *Aphis gossypii* and *Myzus persicae*. Black (15) in 1938 listed eggplant as a susceptible host of potato yellow-dwarf virus, which is not known to occur in Hawaii. Holmes (96) lists eggplant as susceptible to tobacco mosaic virus, tomato spotted wilt virus and tobacco ringspot virus.

Tomato Fern Leaf

The disease in tomatoes known as fern leaf is caused by the presence in tomatoes of the common cucumber mosaic virus. This disease is characterized by stunting of the plant and particularly by reduction or absence of the lamina of the leaves leaving filiform or "shoestring" leaflets.

Smith (215) stated that these symptoms may be produced also by tobacco mosaic virus (tomato mosaic virus) under conditions of low temperature and especially of low light intensity. However, Mogendorff (147) in 1930 reported the results of extensive experiments on the fern leaf problem which do not agree with those reported by Smith. Mogendorff (147) stated that "typical fern-leaf symptoms could not be produced with the ordinary tobacco-mosaic or tomato-mosaic virus (Tobacco virus 1) under any of the environmental conditions to which the infected host was submitted." He found further that fern leaf was produced only irregularly on tomato by cucumber mosaic virus (Cucumber virus 1) if the infection had been accomplished by mechanical means. However, fern leaf could be produced regularly and at will if young tomato plants were infected with cucumber mosaic virus by means of the green peach aphid, *Myzus persicae*. The production of fern leaf symptoms was also found to depend upon (a) the atmospheric temperature and (b) the age of the plants at the time they are infected. The optimum atmospheric temperature for the expression of symptoms was found to lie between 18° and 22° C., with an approximate minimum temperature of 15° C. and an approximate maximum of 25° C. Moreover the tomato plants had to be infected while they were still small if typical fern leaf symptoms were to develop.

Although several different species of aphids have been demonstrated to transmit cucumber mosaic, reports of experiments specifically designed to study fern leaf in tomatoes have not been encountered in which aphids other than *Myzus persicae* were used as the vectors. The fact that Mogendorff found fern leaf could be induced readily by aphid transmission of the virus but only irregularly when the tomato plants were artificially inoculated, is of interest.

Parris (177) reported this disease as being very common in Hawaii. Members of the Vegetable Crops Department of the University of Hawaii Agricultural Experiment Station have informed the writer that the occurrence of tomato fern leaf in Hawaii has been found to be sporadic. The greatest amount appears during the winter months as would be expected in view of Mogendorff's findings regarding temperature and light.

Tobacco and Tomato Mosaic

Synonyms: Tobacco mosaic virus, tomato mosaic virus, pepper mosaic virus.

Mosaic has been known to occur in Hawaii since 1919 when it was recorded on tobacco (*Nicotiana tabacum*) by Carpenter (32).

This virus is of importance not only because of the economic losses which have resulted from the disease it causes, but also because it has figured so prominently in the research on the nature of viruses. The first published record of experimental transmission of a virus disease was by Iwanowski in 1892 who reported that sap of tobacco plants showing mosaic symptoms infected healthy plants after the sap had passed through a bacteria-proof filter.

Working with this same virus, Stanley (218) in 1935 succeeded in isolating and crystallizing the tobacco mosaic virus in what has been considered to be pure or nearly pure form.

There are several strains of tobacco mosaic virus which produce different symptoms in the tobacco plant. The strain which has received most investigation and which is of greatest economic importance is one which we speak of as common tobacco mosaic or tomato mosaic. This is an exceedingly infectious virus and can be transmitted to healthy plants in various ways such as by leaf contact, contaminated tools, clothing or other articles, and through the soil. It withstands drying in tobacco leaves for years without losing the ability to infect healthy plants.

Despite the highly infectious nature of tobacco mosaic virus, it has proved to be one of the most difficult of all viruses to transmit by means of insects. Cleveland (47) in 1931 listed *Thrips tabaci, Epitrix cucumeris* and *Tetranychus telarius* as probable (though unimportant) vectors of tomato mosaic virus. These conclusions were based on the abundance of the species in the field and on a limited number of vector tests. In view of present knowledge

concerning the transmission of this virus, it is highly improbable that these species actually are vectors. For many years it was assumed that aphids were largely responsible for the spread of tobacco mosaic in the field. However, Hoggan (91, 93) in 1931 and 1934 demonstrated that aphid transmission of this mosaic was infrequent when compared with many other aphid-transmitted mosaics. She worked with *Myzus pseudosolani, Myzus persicae, Myzus circumflexus* and *Macrosiphum solanifolii.* According to these experiments the aphids consistently failed to transmit the virus from tobacco to other hosts. However, transmission was obtained with some regularity from tomato to tobacco and other solanaceous hosts. Transmitting efficiency of three species was determined by transferring known numbers of aphids from diseased *Lycopersicon pimpinellifolium* (93) to hybrid plants of *Nicotiana tabacum* x *N. glutinosa* and counting the number of local lesions of tobacco mosaic produced on the hybrid host. This experiment demonstrated that, "with *Myzus pseudosolani,* about 1 aphid in 129 caused infection; with *Macrosiphum solanifolii* about 1 aphid in 140; and with *Myzus persicae* about 1 aphid in 800 or more." Comparative tests in the transmission of a crucifer virus and sugar beet mosaic virus indicated that approximately 1 aphid in 4 or 5 of *Myzus persicae* served as a vector.

Hoggan's experiments were very significant in that they demonstrated the importance of a particular host species being used as the source of the virus in studies of insect transmission.

Parris (177) in 1938 stated that mosaic is the most prevalent tomato virus disease in Hawaii. Of great concern to tomato growers in Hawaii and in other parts of the world is the role of insects in spreading the tobacco mosaic virus from tomato to tomato as tomato mosaic. While Hoggan's experiments demonstrated the ability of *Macrosiphum solanifolii* to transmit mosaic from tomato to tobacco and some other hosts, no experiments have been reported in the literature on the insect transmission of this disease from tomato to tomato. It is conceivable that if aphids can acquire the virus from tomato more readily than from other host plants, they may also be able to infect tomato with greater efficiency than other plants.

Hoggan (93) concluded that it "seems unlikely that any appreciable amount of dissemination of tobacco mosaic may be brought about by aphids, except perhaps from tomato."

In 1937, Chamberlain (45) reported that attempts to transmit mosaic from tobacco, tomato and black nightshade to tobacco by means of *Myzus persicae, M. solani* and *Macrosiphum solanifolii* were unsuccessful in New Zealand. Failure to duplicate Hoggan's results may have been due to differences in technique or possibly even to inherent differences in the transmitting ability of the aphid stocks used.

In 1934 Chamberlain (41) had reported that in New Zealand healthy tomato plants growing next to infected ones did not become infected with mosaic even though the plants had carried many *Macrosiphum solanifolii* and *Myzus solani* early in the season. Absence of rapid spread in a restricted local situation such as reported by Chamberlain does not warrant the conclusion that aphids do not play an important role in the spread of tomato mosaic. The evidence seems convincing that this virus is rarely transmitted by aphids from hosts other than tomato and in all probability spread of the disease by aphids from tomato to tomato is at a relatively low rate when compared with most aphid-transmitted viruses. Nevertheless, even an inefficient vector may be responsible for serious crop losses from virus diseases when the vector occurs in large numbers as does *Macrosiphum solanifolii* in many tomato fields in Hawaii during the cooler months of the year. Such a vector may do its greatest damage by establishing new and scattered foci of infection in a field or region. Even though the number of plants infected by the aphids may be relatively low, the disease may thereby become widely scattered and result in subsequent spread to surrounding plants by more efficient means of transmission such as leaf contact, or contamination of clothing, tools and machinery.

There is a definite need for determining the role of aphids in the spread of tomato mosaic in Hawaii.

Tomato Streak

This virus disease of tomatoes was reported by Parris (177) to be present in Hawaii. He also described the disease symptoms. According to information received from the Vegetable Crops Department of the University of Hawaii Agricultural Experiment Station, this disease, though present, is not common in Hawaii. Smith (215) calls this virus Lycopersicum virus 1 and states that it is similar to, but distinct from, tobacco mosaic virus. Parris (177), on the basis of a report by Jones and Burnett (108), described it as a combination of tomato mosaic virus and potato mottle or X virus in tomato. However, Holmes (96) treats it as a single strain of tobacco mosaic. It has not been shown to be transmissible by insects. However, if ordinary tomato mosaic (tobacco mosaic) is a component part, this portion could be transmitted by the aphid vectors reported for tobacco mosaic.

Tomato Mottle Mosaic

This disease, characterized by faint interveinal mottling and some necrotic spots on the leaves, was reported by Parris (177) to occur in Hawaii but it is not common. It was reported (177) to be caused by the potato mottle virus (X virus) in tomato. No insect vector is known.

Tomato Spot Necrosis

Parris (177) listed this disease as occurring in Hawaii. However, it is not considered common in the Territory. According to Jones and Burnett (108) it is caused by the presence in tomato of rugose mosaic virus of potato. Rugose mosaic is produced by a combination of potato mottle virus (potato latent or X virus) and the veinbanding virus described by Dykstra (55). A similar disease of tomatoes produced by potato mottle virus in combination with a strain of tobacco mosaic virus is described by Holmes (96). Tomato spot necrosis has not been demonstrated to be insect transmissible although one of its components, veinbanding, is readily transmitted by *Myzus persicae* and *Macrosiphum solanifolii* (113).

Tomato Veinbanding Virus

This is the component of rugose mosaic of potato which is transmitted by *Myzus persicae* and *Macrosiphum solanifolii* (113). Parris (177) recorded its occurrence in Hawaii and stated that its detrimental effect on the plant is of minor importance.

Tomato Aucuba Mosaic

Parris (177) reported aucuba (yellow) mosaic of tomato in Hawaii but it is not common. No insect vectors are known.

Spotted Wilt

(Caused by spotted wilt virus, typical strain, *Lethum australiense* var. *typicum* Holmes)

Synonyms: Pineapple yellow spot virus, Ananas virus 1, Tomato virus 1, Lycopersicum virus 3, Kromnek disease virus of tobacco and tomato, "Vira-Cabeça" virus of tobacco and tomato, "Corcova" virus of tobacco and tomato.

Spotted wilt is an important virus disease in many parts of the world. Since its discovery in Australia (31) it has been reported from all of the main regions of the world except the Orient. Norris (157) in 1943 reported the presence in Australia of three strains of spotted wilt virus. These were designated as mild strain, ringspot strain and necrotic strain. The necrotic strain was purified and Norris stated that it appeared to be identical with the virus described from Oregon by Milbrath (146) in 1939, as tomato tip blight. Holmes (96) lists tip blight as a distinct strain of spotted wilt.

Insect transmission. Sakimura (200) in 1940 presented a review of the literature published up to 1939 on spotted wilt with particular reference to the insect vectors. Pittman (187) in 1927 reported transmission of spotted wilt virus in Australia by means of *Thrips tabaci*. Samuel *et al.* (201) and Bald *et al.* (8) in 1930 and 1931 demonstrated that the virus was transmitted in Australia by two species of thrips. One is a species of *Frankliniella*, listed in most

literature as *F. insularis* Franklin. The other is *Thrips tabaci.* The identity of the *Frankliniella* species has been the cause of much confusion. Samuel *et al.* (201) reported that the species used in their transmission test was identified by Dr. G. D. Morison as *Frankliniella insularis.* However, other material from the same source was sent to A. A. Girault in Queensland who described the thrips as a new species, *Parafrankliniella nigripes,* in 1928. Girault's description was ignored and, when the fact became apparent that the use of the name *insularis* was based upon a misidentification, Andrewartha (5) in 1937 described the species as new under the name *F. lycopersici.* This latter name was used by Sakimura (200), Leach (122) and others. However, since the species was validly described as *nigripes* by Girault in 1928, the name *lycopersici* And., applied in 1937, must be considered a synonym. The common spotted wilt vector of Australia is therefore *F. nigripes* (Girault) as listed by Essig (61) in 1942.

Samuel *et al.* (201) and Bald *et al.* (8), in addition to determining two vectors of spotted wilt virus, also reported on the unusual specific relationships which exist between the virus and the vectors. The virus must be acquired by the thrips while the latter are still in the larval stage. The virus is retained through pupation, and the emerging adults may serve as vectors. If the adult stage has been attained before the thrips are permitted to feed on virus inoculum, they are incapable of serving as vectors.

Linford (125) in 1932 reported transmission of yellow spot of pineapple in Hawaii by means of *T. tabaci.* At the time this work was done, the coidentity of yellow spot and spotted wilt was not known although Linford noted that the peculiar relationship of the virus to the vector (which he discovered independently) was the same as that existing between spotted wilt and its vectors. The virus has a relatively long incubation period in the vectors, varying from 5 to 10 days. In Hawaii this was found by Linford to be approximately 10 days in *T. tabaci.*

Bailey (6) in 1935 reported that *T. tabaci* in Hawaii was found by Dr. Carter to retain the virus for about 30 days during adult life.

Smith (211, 213) in 1931 and 1932 demonstrated that *T. tabaci* is the vector of spotted wilt in England. Gardner *et al.* (76, 77, 78) in 1934, 1935 and 1937 reported transmission of spotted wilt to a large number of plant species in California by means of *T. tabaci* and *Frankliniella moultoni* Hood. In 1936 Essig and Michelbacher (62) and in 1942 Essig (61) cited *F. occidentalis* Perg. as a vector in California. Sakimura (200) reported that he had been informed in private correspondence from Dr. S. F. Bailey, of the University of California, that the inclusion by Essig and Michelbacher of *F. occidentalis* Perg. in the place of *F. moultoni* Hood "is a matter of different view on the classification of the species."

Moore and Anderson (148, 149) in 1933 and 1939 discussed Kromnek disease of tobacco and tomato in South Africa where transmission was obtained by means of *Frankliniella schultzei* and *T. tabaci*. These authors stated (149) that the virus is probably identical with spotted wilt of Australia, Europe and America. Carter (37) in 1939 reported his observations on the Kromnek disease of South Africa. Here he found, in fields surrounded by Kromnek-diseased weeds, symptoms on pineapple, indistinguishable from yellow spot of pineapple in Hawaii. *F. schultzei*, vector of Kromnek disease, was also found in the flowers of pineapple.

Silberschmidt (207) in 1937 announced that Dr. Santos Costa had obtained transmission of "Vira-Cabeça" disease of tobacco in Brazil by means of *tabaci* and *Frankliniella* sp. Sakimura (200) quoted personal correspondence regarding the identity of the Brazil disease and its vector as follows: "Dr. A. S. Costa . . . recently informed the writer that the virus of 'Vira-Cabeça' of tobacco and tomato, widely distributed in Brazil, has been proven to be identical with S. W. (spotted wilt) virus; that the vector is a species of *Frankliniella*, possibly *F. paucispinosa* Moulton, which is also known to be the vector of 'Corcova' of tobacco and tomato in Argentina."

In 1938 and 1940 Fawcett (64, 65) reported transmission of "black pest" of tomatoes ("Corcova" disease of tobacco) in Argentina by means of *F. paucispinosa*, and stated the disease appeared to be identical with spotted wilt. The same author announced (65) that "Vira-Cabeça" of Brazil appeared to be identical with "Corcova" of Argentina.

Host range of spotted wilt virus. The host range of this virus is very large. Smith (215) listed over 100 susceptible species which occur in 23 different families. Most of them occur among the dicotyledons but some are monocotyledonous species. More host plants of the virus have been found in the Solanaceae than in any other family. In tomato, the disease is very destructive in several parts of the world.

In Hawaii, Kikuta *et al.* (112) in 1945 announced the development of a tomato variety, Pearl Harbor, which is resistant to Hawaiian spotted wilt. However, they suggest that preliminary tests with the Pearl Harbor variety in other parts of the world indicate it may not possess resistance to some strains of the spotted wilt virus.

In peas, spotted wilt virus causes streaking and necrosis of pods, stems and leaves. In 1931 Linford (124) transmitted pineapple yellow spot virus from *Emilia sonchifolia* to peas by means of *T. tabaci* and noted that the symptoms appeared to be identical with the pea streak he had observed at various localities across the United States. He suggested that the pea streak on the mainland was caused by the same or a related virus. At the time of this

report the coidentity of yellow spot and spotted wilt had not been established. In 1936 Whipple (239) transmitted spotted wilt to peas by *T. tabaci* and obtained typical pea streak symptoms.

Yellow Spot of Pineapple

(Caused by spotted wilt virus in pineapple)

This disease, first reported publicly by Illingworth (97) in 1931, was discovered in Hawaii in 1926. Its sudden appearance, rapid spread in some areas during the first few years, and the destructive effect produced on the pineapple plant appeared to mark this disease as a major pineapple problem. The steps leading to the determination of the insect vector of the disease in Hawaii constitute an interesting record since it provides an instance in which the probable identity of the vector group was established before the vector had actually been observed as a pineapple inhabiting insect. The procedure has been discussed by Illingworth (97) and Linford (125). Illingworth carried out preliminary exploratory experiments in search of the vector. The investigations which established the identity of the vector were conducted by Linford. Undetermined *Nysius,* aphids, leafhoppers, thrips, chironomid maggots, nitidulid beetles, spring tails, red spiders, tarsonemid mites as well as the pineapple mealy bug, bud-moth caterpillars and *Scolia manilae* Ashm. wasps were tested without success by Illingworth (97). Dr. R. N. Chapman (97, 125) then discovered microscopic insect punctures associated with the yellow spot symptom on the pineapple leaves. These were first assumed to be the feeding punctures of a relatively large sucking insect. However, Linford (125) discovered that the punctures represented the oviposition site of a small insect as evidenced by the finding of egg membranes in the reniform cavities beneath the surface openings. The only insects which seemed to fit the specifications for such a puncture were thrips. This was demonstrated subsequently by the findings of unhatched eggs, from which thrips emerged, in pineapple leaves taken from a disease-infected area. As these investigations were proceeding, another host plant of the virus was also being sought. The presence of a similar disease on *Emilia sonchifolia* in infected areas resulted in the investigation of this plant, its virus disease and the thrips, *Thrips tabaci,* which infested it. Proof of the vector's identity was established soon thereafter. When thrips were transferred from diseased *Emilia* to healthy pineapple, typical yellow spot disease was transmitted.

In addition to *sonchifolia, Emilia* species designated as *Emilia* No. 3 and *Emilia* No. 4 have been reported by Sakimura (198) to serve as host plants for the virus and for the thrips vector in Hawaii. Other host plants of *Thrips tabaci* in Hawaii and its life history on *Emilia sonchifolia* have been reported by Sakimura (197).

Sakimura (199) in 1940 demonstrated in a long series of tests that *Thrips nigropilosus* Uzel is not able to transmit spotted wilt virus (yellow spot virus) in Hawaii. Preliminary transmission tests with *Hercinothrips femoralis* (Reuter) were also negative (199).

The fact that the yellow spot disease did not become a limiting factor to pineapple production as had been feared, but has remained a minor problem except for occasional outbreaks, is due to the host plant preference shown by the vector as discussed by Carter (35, 38). Pineapple normally is not a host of *Thrips tabaci* which, in Hawaii, breeds preferentially on *Emilia.* Furthermore, Carter (38) reported that "Incidence of yellow spot disease in pineapple is not correlated with *Thrips tabaci* populations on *Emilia* in nearby areas. This is accounted for on the grounds that *Emilia* is a favored host from which dispersal does not normally occur." Factors which may be responsible for the occasional sporadic movement of thrips from infective *Emilia* to pineapple plants are destruction of the *Emilia* by means of cultivation or drought (38).

Although the possibility was considered for some time that tomato spotted wilt virus and pineapple yellow spot virus were the same, their coidentity was not well established until 1940 when Sakimura (200) and Parris (181) published results of their investigations in Hawaii. By means of *Thrips tabaci,* Sakimura transmitted yellow spot virus to and from spinach, broad bean, celery, potato, eggplant, bell pepper, tomato, tobacco, *Nicotiana glutinosa* L., *Datura stramonium* L., petunia, chicory, endive and lettuce, all of which are known to be susceptible to the spotted wilt virus. The symptoms produced were identical with those recorded for spotted wilt. Plants known to be immune from spotted wilt virus were also found to be immune to yellow spot virus.

Parris (181) transmitted the tomato spotted wilt virus mechanically from tomato to tomato and potato and from *Emilia sonchifolia* to *Emilia* and tomato. On the basis of host range and symptoms, he concluded that tomato spotted wilt and pineapple yellow spot were probably caused by the same virus.

The joint study of this problem by Sakimura and Parris was undertaken after an outbreak of a tomato disease, which appeared to be identical with spotted wilt (176), occurred in Hawaii in 1937. This situation provided the opportunity and need for determining the relationship of pineapple yellow spot and tomato spotted wilt.

Tomato Tip Blight

Synonyms: Tomato spotted wilt virus, tip blight strain (*Lethum australiense* var. *lethale* Holmes).

Martin (138) in 1943 reported the presence in Hawaii of a tomato disease which he considered distinct from spotted wilt and believed would prove to be tomato tip blight as reported by Milbrath (146) in 1939 in Oregon. The properties of the virus were

studied by Milbrath (146), who considered the disease to be new. Transmission was obtained by means of *Thrips tabaci* (146).

The writer is following Holmes (96) and Norris (157) in classifying this as a strain of spotted wilt virus. Norris studied three strains of tomato spotted wilt virus in Australia, one of these, designated as necrotic strain, was discussed by Norris in part as follows: "This strain appears to be identical with the virus described by Milbrath in Oregon as tomato tip blight. The symptoms produced on tomato, tobacco, and other hosts correspond closely. In Oregon this necrotic strain was apparently separated out by chance from the others, but its occurrence in close association with ordinary spotted wilt was observed. Milbrath also noted that occasionally both viruses occurred together in tomato. In such cases it would appear that other strains were present but that the necrotic strain occurred in very high concentration."

The fact that tomato tip blight is transmitted by *Thrips tabaci*, suggests strongly that the affinity of this virus and that of spotted wilt is exceedingly close, because this thrips species has not yet been incriminated as a vector of any virus proven to be outside of the spotted wilt complex.

Potato Virus Diseases in Hawaii

Virus diseases, if prevalent in potato plantings, seriously reduce the crop yields in quantity. Parris (176, 177) reported figures on yield reduction in Hawaii due to the use of virus diseased seed stock. Dr. W. A. Frazier, of the University of Hawaii has informed the writer[11] that in Hawaii potato losses due to virus diseases are not ordinarily very serious in areas where mainland-grown certified seed is used. However, the practice of some farmers of using seed grown locally often results in very serious losses due to potato viruses. This is due to the fact that potato viruses are transmitted through the tubers. If disease-free seed is used in Hawaii, most of the plants escape virus infection until late in the season when it is too late for the virus to injure the crop materially. However, before they are harvested, many normal-appearing tubers may contract virus infection. When such tubers are used as seed for subsequent crops a number of diseased plants are produced early in the season. These provide sources of infection from which insect vectors may transmit the viruses to surrounding healthy plants. Seed stock should therefore be obtained from areas which are relatively free from potato virus diseases.

Although no transmission experiments involving potato viruses have been reported in Hawaii, Parris (177) listed the following diseases as occurring in the Territory: mottle, mild mosaic, crinkle mosaic, leaf rolling mosaic, veinbanding, rugose mosaic, and leaf roll.

[11] Personal communication.

Potato Mottle Virus

Synonyms: Latent virus; "healthy potato virus"; Virus X.

Dykstra (55) in 1939 reviewed the literature on this—the most ubiquitous of all potato viruses known. It has been shown to be present in masked form in all the tubers of most, and perhaps all, of the commonly used varieties of "apparently healthy" potatoes. In Europe this virus has been found to produce a mild form of mottling in some varieties.

Dykstra (55) transmitted this virus to *Amaranthus retroflexus* and stated, "This is believed to be the only potato virus that has been successfully transmitted to plants outside the Solanaceae." Alone or in combination with other viruses it causes diseases of potato, tomato, pepper and other plants.

Holmes (96) classifies this virus into three strains, (a) potato ringspot strain, which is masked in potato but produces systemic necrosis and ring shaped lesions on tobacco and pepper; (b) yellow-mottle strain, which imparts a yellow cast to potato foliage and in tomato causes yellow-mottling mosaic and occasional necrosis of the young leaves (see tomato mottle mosaic); (c) masked-mottle strain, which produces symptomless systemic infection in potato, tobacco and *Datura stramonium,* but which produces systemic necroses in pepper.

No insect vector has been found capable of transmitting any of the strains of potato mottle virus.

Potato Mild Mosaic

According to Dykstra (55) the mild mosaic virus, in the absence of the mottle or X virus, causes only a very faint mottling in the potato foliage. However, in combination with virus X (which alone shows no symptoms in many potato varieties) mild mosaic produces a pronounced mottling and crinkling of the foliage. According to Parris (177) plants produced from tubers infected with mild mosaic may die prematurely.

Holmes (96) listed *Aphis rhamni* B. de Fonsc. (= *A. abbreviata* Patch) and *Myzus persicae* as the vectors of potato mild mosaic. However, Dykstra and Whitaker (57) in 1938 reported experiments which demonstrated that this virus can be transmitted by *Myzus persicae, M. circumflexus, M. solani,* and *Macrosiphum solanifolii.*

Reports from the Vegetable Crops Department of the University of Hawaii Agricultural Experiment Station indicate that this virus is common in some potato plantings in Hawaii.

Potato Crinkle Mosaic

This disease is similar to mild mosaic but differs in that the leaflets are more ruffled and the mottle areas are larger. Like mild mosaic and rugose mosaic it is a composite disease composed of

the mottle or X virus and at least one other component. When X virus is removed, the remaining component causes only a faint mottling. When X virus is added, the mottling becomes pronounced and the leaves become crinkled (55).

Dykstra and Whitaker (57) reported transmission of crinkle mosaic free from X virus by means of the same aphids which transmitted mild mosaic, i.e. *Myzus persicae, Myzus solani, M. circumflexus* and *Macrosiphum solanifolii.* As in the case of mild mosaic and rugose mosaic, the aphids transmitted not the disease as named, but only one component since X virus, the other necessary component, is not transmitted by insects. The percentage of positive transmission varied from 0 to 100 per cent in different experiments.

Potato Leaf Rolling Mosaic

This disease discussed by Smith (215) under the name Solanum virus 11, is characterized by a diffused mottling and an upward rolling of the leaves which are flaccid and resemble the rolling of leaves on plants affected with *Rhizoctonia* or blackleg (55, 215). It differs from leaf roll in that the plants are not dwarfed and the leaves are not tough. Schultz and Folsom (203), who originally described the disease, reported transmission by means of unspecified aphids. No report of insect transmission has been published by other workers.

Potato Veinbanding Virus

Holmes (96) classifies this virus as cucumber mosaic virus, veinbanding strain.

Smith (215) lists veinbanding virus, potato virus Y and stipple streak virus as synonyms of Solanum virus 2. Dykstra (55), however, treats veinbanding, Y and stipple streak viruses as related but distinct strains.

Veinbanding is transmitted by *Myzus persicae, M. solani, M. circumflexus,* and *Macrosiphum solanifolii* (57, 113). This virus is characterized by crinkling and downward curling of the leaves. The veins of older leaves become necrotic. Diseased plants are stunted and usually die prematurely (55). This virus in combination with the potato mottle or X virus produces rugose mosaic of potato (55).

Potato Rugose Mosaic

This disease is the result of the presence in potato of mottle or X virus and the veinbanding virus. Since the X virus component of rugose mosaic is not transmitted by insects, the records of insect transmission of rugose mosaic actually refer to transmission of the veinbanding component (see "Veinbanding Virus"). However, the almost universal occurrence of mottle or X virus in potato means that whenever veinbanding virus is transmitted to a potato plant, the resultant disease will probably be rugose mosaic.

According to Smith (215), the characteristics of this disease are: mottling of the upper leaves and dark, necrotic veins on the lower leaves, and crinkled and rugose foliage. Severely affected plants are stunted and the tubers are small. The mottle symptoms may be masked by high temperatures, but the rugosity and stunting persist.

This disease is sometimes serious in Hawaii.

Potato Leaf Roll

Potato leaf roll is considered by Smith (215) to be the principal cause of potato degeneration in several parts of Europe and the British Isles. It is also common in some parts of North America. In Hawaii, leaf roll has not been a serious problem.

The symptoms of leaf roll make it relatively easy to identify. The leaves of diseased plants are rolled, thick, rigid and leathery. This is reportedly due to an abnormally high starch content which, in turn, results from prevention of normal food translocation in the plant because of phloem necrosis in the stems. Affected plants are dwarfed and tubers are reduced in size and number. This virus has not been found to be transmissible by mechanical means.

Insect transmission. Many workers have reported insect transmission of leaf roll and the accounts are sometimes conflicting. Vectors have been reported as follows: *Aphis rumicis* L. and *Myzus persicae* by Ortwijn Botjes (165) in 1920; *Calcoris bipunctatus,* a plant bug, and *Typhlocyba ulmi* (Linn.), a leafhopper, by Murphy (151) in 1923; *Macrosiphum solanifolii* and *Myzus pseudosolani* by Murphy and McKay (152) in 1929; *Myzus persicae, M. pseudosolani, Aphis rhamni, Eupteryx auratus, Lygus* sp., *Psylliodis affinis,* and the larvae of *Tipula paludosa* by Elze (59) in 1927, the last species being listed as an underground vector; *Macrosiphum solanifolii, Myzus persicae* and *Empoasca fabae* by Cleveland (47) in 1931 with the latter two species listed as the main vectors in Indiana. Smith (210, 212, 215) in 1929, 1931 and 1934 failed to transmit the virus by means of *Calcoris bipunctatus, Lygus pabulinus, Eupteryx auratus, Chlorita viridula, Psylliodis affinis,* and *Macrosiphum gei,* (= *solanifolii*) but obtained transmission with *Myzus persicae, M. pseudosolani* and *M. circumflexus.*

This disease is of singular interest because of the unusual relationship known to exist between the virus and *Myzus persicae,* one of its vectors (215). After this aphid has fed on leaf roll inoculum, an incubation period of from 48 to 54 hours is required before *Myzus persicae* can infect a healthy plant. Furthermore, this species retains the virus in an infective condition for long periods of time while feeding on plants which are immune to the virus. A similar relationship has been reported by Osborn (168, 170) to exist between pea enation mosaic virus and its two vectors, *Macrosiphum*

pisi and *M. solanifolii,* and by Ocfemia and Buhay (160) for *Pentalonia nigronervosa* in transmitting abacá bunchy top virus in the Philippines. Except for a few cases such as these, other aphid-transmitted viruses are reported to require no incubation period in the aphid vectors. Also, such viruses are not retained by their vectors for more than a few hours at most after the last feeding on virus inoculum.

Dykstra and Whitaker (57) reported that transmission experiments using *Myzus persicae, M. circumflexus, M. pseudosolani* and *Macrosiphum solanifolii* resulted in a high percentage of potato leaf roll virus transmission by means of the *Myzus* species. *Macrosiphum solanifolii* proved to be a relatively inefficient vector in most experiments, although occasionally a high percentage of transmission was accomplished with this species. A possible explanation was suggested for the difference in transmitting ability demonstrated by the aphids. This explanation was based on the tissues in which the aphids habitually fed. The three species of *Myzus* were found to feed in the phloem in practically all cases. They exhibited approximately equally high efficiency as vectors of the disease. *Macrosiphum solanifolii* fed in the vascular tissues in only 46 per cent of the cases observed. This suggests that phloem feeding may be necessary for the aphids to acquire and/or transmit the virus.

This explanation is a logical one in view of what is now known regarding the relation of viruses to plant tissues. Bennett (12) has contributed greatly to our understanding of this problem. He has demonstrated that leaf-curl of raspberry and curly top of sugar beet are caused by viruses apparently closely limited to the phloem. He also pointed out that several other diseases, including potato leaf roll, which exhibit symptoms resulting from phloem disturbances, are not transmissible mechanically and ordinarily show the type of vector-virus relationship described for *M. persicae* and leaf roll virus.

The reported ability of many of the species listed as vectors of leaf roll needs further confirmation. In view of the incubation period of the virus and its long retention in *Myzus persicae,* and the fact that the disease is not mechanically transmissible, it seems somewhat doubtful that this virus could be transmitted by so many unrelated insect species, some of which would have to transmit the virus in a purely mechanical fashion.

Bamboo Mosaic

Kunkel (114) in 1921 reported that what appeared to be mosaic had been observed several times on *Bambusa vulgaris* Wendl. in Hawaii. No further reference has been made in the literature to the disease.

Canna Mosaic

Kunkel (114) in 1921 stated that mosaic had frequently been observed on *Canna indica* L. in Hawaii. No investigations of the virus or its manner of spread have been conducted.

Dianella odorata Bl. Mosaic

Kunkel (114) in 1921 reported that in Hawaii "A disease closely resembling the yellow stripe disease of sugar cane occurs on *Dianella odorata* Bl." This plant belongs in the lily family.

Hippeastrum Mosaic

In 1922 and 1924 (116, 117) Kunkel reported the common occurrence in Hawaii of a mosaic disease of *Hippeastrum equestre* Herb. This plant (commonly known as Barbados lily) is grown as an ornamental in Hawaii, but has also escaped from cultivation and grows wild in some of the valleys above Honolulu. Kunkel's investigation of the virus was primarily concerned with the study of amoeboid bodies in the cells of virus-diseased plants, but he was also interested in the manner in which the disease was disseminated in nature. Potted plants kept in insect-proof cages remained healthy, while most of those kept outside, a short distance from diseased plants, became infected with mosaic. These results suggested insect transmission. Kunkel made several attempts to transmit the virus by means of the corn aphid, *Aphis maidis*, but all tests were negative.

Smith (215) reported *Hippeastrum* sp. as a host of tomato spotted wilt virus in England, but the symptoms produced by this virus are distinct from those described by Kunkel for Hippeastrum mosaic in Hawaii.

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A New Species of Lepidosaphes Attacking Dendrobium Orchids in Hawaii and California (Homoptera: Coccoidea: Diaspididae)

By HOWARD L. McKENZIE
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Sacramento, California

(Presented at the meeting of August 13, 1945)

During 1944 the California State Department of Agriculture, Bureau of Entomology and Plant Quarantine received for determination a species of scale insect heavily infesting pseudobulbs of *Dendrobium dearei* orchids at Honolulu, Hawaii. The orchid plants were presumably treated before entry into California, because no living scale insects were observed on the submitted plant portions. The material was submitted by D. T. Fullaway, Territorial Entomologist, who in correspondence, indicated the insect had been observed for several years doing considerable damage to orchid plants. Mr. Fullaway was under the impression that the species concerned might be the same as one recently described by the author as *Lepidosaphes mackieana.* An examination of the submitted specimens indicates the species is not *mackieana,* but instead, represents, as here interpreted, still another new species of this group. Specimens submitted early in 1944 by M. R. Bell, Inspector State Nursery Service, from *Dendrobium dearei* in a nursery at San Leandro, Alameda County, California were found to be identical with this species.

Since this scale insect has been causing damage to *Dendrobium* orchids in Hawaii, Mr. Fullaway has kindly suggested its description be included in the Proceedings of the Hawaiian Entomological Society. A description of the insect follows:

Lepidosaphes noxia McKenzie, new species (figure 1)

HISTORICAL BACKGROUND. This species of *Lepidosaphes* was first collected at San Leandro, Alameda County, California in a commercial orchid nursery, on *Dendrobium dearei,* February 9, 1944 by M. R. Bell, State Nursery Inspector. Additional insect material was requested of Mr. Bell, and on March 8, 1944 a second collection was made by him from the same plants in the same nursery. Still another collection was made from the same host and locality on June 26, 1944 by J. B. Steinweden of this Department, and observations on extent and intensity of infestation were made by him. He has indicated that approximately 12 plants were found lightly infested with the scale, and that it was apparently being held in control in the nursery at San Leandro.

Prepared slide mounts of this species collected at Honolulu, Hawaii on *Dendrobium dearei* during April 1944 by William Kirch were submitted to this office for determination during May 1944 by D. T. Fullaway, Territorial Entomologist. Upon request, subsequent treated fresh material collected at Honolulu, July 19, 1944 by William Kirch, on pseudobulbs of the same host, was sent to the author by Mr. Fullaway. Mr. Fullaway indicated by correspond-

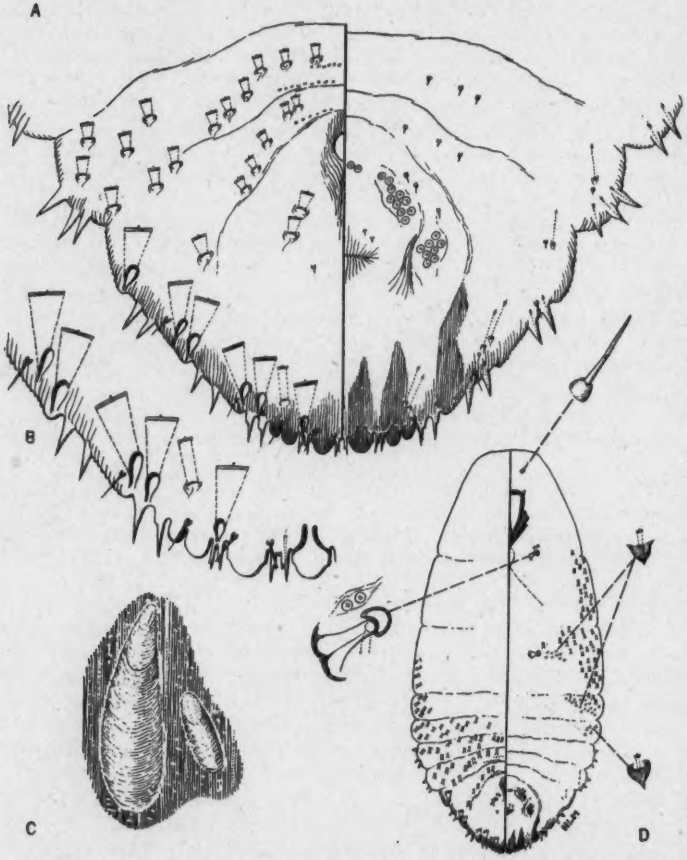

Figure 1.—*Lepidosaphes noxia* McKenzie, new species. A, pygidium of the adult female; B, details of the dorsal aspect of the pygidial margin; C, habit; D, body of adult female. Unlettered details are connected to their points of origin by guide lines and should be readily identifiable.

ence, that the scale has been noticed for several years doing considerable damage to orchid plants of the *Dendrobium* group. The infested pseudobulb material sent to the present author by Mr. Fullaway showed marked damage to the orchid tissue particularly where the leaves are attached to the leads. This visible injury causes death to the leaves.

HOSTS AND DISTRIBUTION. Type and paratypes from orchid, *Dendrobium dearei*, in a commercial orchid nursery, San Leandro, Alameda County, California, collected February 9 and March 8, 1944 by M. R. Bell, State Nursery Inspector. Additional paratypes on pseudobulbs of the same host are available from Honolulu, Hawaii, collected July 19, 1944 by William Kirch.

HABIT. Scale insects occurring on the leads of orchids concentrating particularly where the leaf partially surrounds the lead. Scale of the female averages about 2.2 mm. long, pale brown, exuvium terminal; male smaller, much lighter in color than female, exuvium terminal.

RECOGNITION CHARACTERS. Length as mounted on microscope slide averages approximately 1.25 mm.; derm membranous at full maturity; abdominal segments but little produced laterally; antenna one-spined; perivulvar pores present in five groups, anterior groups ranging from 3-7, average 4, median ranging from 7-14, average 10, posterior group ranging from 4-9, average 7; median pygidial lobes relatively small, low and rounded apically, slightly once-notched on each side, second lobes bilobed, quite large and prominent in comparison with median pair; dorsal macroducts much smaller than marginal ones of pygidium, occurring across prepygidial abdominal segments 2-4 inclusive, and marginally only on first abdominal segment and metathorax, submedian macroduct group on sixth segment containing usually two ducts, on each side, a smaller, dorsal macroduct present slightly anterior to second pygidial lobes; ventral microducts and gland tubercles situated as indicated in accompanying figure.

NOTES. *Lepidosaphes noxia* will run to *L. newsteadi* (Sulc) in Ferris' key to species of this group, included in his Atlas of Scale Insects of North America published in 1942. It is structurally quite similar to that species except for its possession of a small dorsal macroduct located slightly anterior to the second pygidial lobes, and more numerous median groups of perivulvar pores. It is also closely related to *L. mackieana* McKenzie, but differs in the character of the median lobes which are only slightly once-notched on each side, whereas in *mackieana* they are laterally serrate, and also in the possession of only one-spined antenna as compared to two-spined in *mackieana*.

The type specimen of *Lepidosaphes noxia* will be deposited in the State Department of Agriculture collection at Sacramento, California, and paratypes in the Federal Bureau of Entomology and Plant Quarantine collection at Washington, D.C.

The accompanying figures were prepared by the author from type material.

A New Apanteles from Hawaii (Hymenoptera: Braconidae)

By C. F. W. MUESEBECK
Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

(Presented at the meeting of August 13, 1945)

By virtue of its conspicuously fasciate wings and banded female antennae this is one of the most striking species of *Apanteles* known to me.

Apanteles trifasciatus, new species

Female.—Length 3 mm. Head very nearly as wide as thorax; face shining, evenly covered with shallow, separated punctures, and with a median longitudinal keel above middle; malar space shorter than clypeus; vertex and temple closely punctate and dull. Thorax stout; mesoscutum with well separated, sharp punctures over most of its surface, subopaque except for a median area on posterior third and a smaller area at each of posterior lateral angles which are impunctate and polished; disc of scutellum evenly convex, impunctate, polished; scutellar furrow with about 10 foveae; polished area on lateral face of scutellum transverse, twice as broad as long, the large area in front of it mostly smooth; propodeum rugulose medially and apically, smooth and shining each side of middle on basal half, areola indicated but its margins low and irregular; mesopleuron impunctate and polished above the longitudinal impression, which is more or less aciculate and has a few indistinct shallow foveae; metapleuron impunctate, polished; posterior coxa impunctate, polished, strikingly compressed and almost keeled above; inner calcarium of hind tibia twice as long as outer but barely half as long as metatarsus; metacarpus a little longer than stigma; first abscissa of radius slightly longer than intercubitus, which it joins in a sharp angle; stub of second abscissa of radius as long as petiole of first discoidal cell; cubitus beyond intercubitus unusually long, longer than first abscissa of radius; nervellus straight, nearly perpendicular to mediella. Abdomen rather slender, widest at third tergite; plate of first tergite about as broad at apex as at base, broadest at the middle with the margins slightly bowed, longitudinally rugulose except on basal middle and at extreme apex, where it is smooth and polished; plate of second tergite transverse, much broader at base and more than twice as broad at apex as long, entirely smooth and polished; following tergites smooth and shining; ovipositor sheath about as long as abdomen, slightly shorter than the unusually long posterior tarsus, very slender but broadening slightly toward apex.

Black; face a little reddish medially below antennae; maxillary palpi dark basally, the apical three segments lighter; scape yellow; pedicel and basal six flagellar segments brown, these followed by four or five yellow segments beyond which antenna is dark brown or blackish; anterior leg yellowish, coxa brown; middle leg light brown, base of tibia white, tarsus yellowish; hind leg brownish black, trochanter brownish yellow, tibia, except for a broad white basal annulus, and metatarsus black, second and following segments of tarsus yellow; wings hyaline, anterior wing with a broad, dark fuscous band basad of a line extending from petiole of first discoidal cell, another slightly narrower band extending from stigma to posterior margin, and apex of wing broadly but not so deeply infumated; hind wing entirely hyaline; abdomen black; second tergite and base of third red; ovipositor sheath brown.

Male.—Like the female except for the uniformly dark brown antennal flagellum, the absence of the first transverse band of anterior wing, and the much shorter abdomen.

Type.—U. S. National Museum No. 57277.

Type locality.—Honolulu, Hawaii.

Described from 8 females and 2 males reared by August Busck, August 1915, from cotton bolls; 1 male labeled "Kaumama, Hilo, Hawaii, Aug. 22, 1927, M. Maneki Coll."; and 3 females and 6 males labeled "S. E. Koolau Mts., Palolo, Oahu, May 18, 1914, J. C. Bridwell Coll." The national collection has, in addition, 1 female labeled as having been collected by R. G. Oakley on an airplane arriving at Guam, August 11, 1938, from Hawaii.

The Synonymy and Distribution of Trichocorixa reticulata (Guérin-Méneville) Hemiptera: Corixidae

By R. I. SAILER
Bureau of Entomology and Plant Quarantine, Agricultural Research Administration, U. S. Department of Agriculture

(Presented at the meeting of October 8, 1945)

It seems advisable to publish certain information concerning *Trichocorixa reticulata* (Guérin-Méneville) in order that this name may be available for use in the manual of Hawaiian insects now being prepared by E. C. Zimmerman. This species is the only known representative of the family Corixidae in the Hawaiian Islands, where it has been reported by F. X. Williams (*26,* p. 195*) as numerous in lowland streams and pools and "fairly swarming in salty pools separated from the ocean by a low sandbar and having a salinity . . . greater . . . than the sea itself." As is indicated by this note, as well as by many additional records, *T. reticulata* is among the few aquatic insects sufficiently adaptable to live successfully in both fresh and saline water. As might then be expected, it is an extremely successful species both in numbers and distribution. The inadequate state of the taxonomy of the Corixidae, as well as failure to comprehend possible distributional limits of so versatile a form, resulted in this species having been named four times from as many widely separated localities. In 1857 specimens from Cuba were named *Corisa reticulata* by Guérin-Méneville. In 1859 specimens from California were named *Corixa wallengreni* by Stål. In 1877 Buchanan F. White named the Hawaiian representatives of this species *Corixa blackburni*, and in 1901 it was named *Corixa mariae* by Champion, this time from the Tres Marias Islands. In 1929 (*12, p. 24*) Lundblad correctly placed *blackburni* White, 1877, as a synonym of *wallengreni* Stål, 1859. In 1931 (*16, p. 214*) and again in 1939 (*25, p. 284*) Jaczewski suggested that *mariae* Champion, 1901, was also a synonym of *wallengreni*. As a result of studies of type specimens made by H. B. Hungerford in 1927 at the British Museum of Natural History and the Paris Museum of Natural History, the notes of which he generously made available for my use, I am able to place both *mariae* and *wallengreni* definitely by synonyms of *Trichocorixa reticulata* (Guérin-Méneville, 1857). Because of confusion concerning the type specimen of *reticulata*, notes on the type series, written by Hungerford during his visit to the Paris Museum, are quoted here in their entirety.

* Figures in parentheses refer to the bibliography at the end of this paper.

"*Corixa reticulata* Guérin. 5 specimens: Museum Paris, Cuba, Coll. Guérin-Ménév., ex-coll. A. Salle 1857.

"Here I believe are two species! Three specimens bear old written labels.—Two: a male and female are labeled '*Corixa reticulata* Guérin (type) Cuba male (or female).' In the same handwriting on the same sort of paper the third specimen is labeled '*Corixa reticulata* Signoret Manuscript. Male Cuba.' This third specimen is not the same species as the first male. It has a narrower interocular space and differently shaped strigil.

"I am placing a red label on the male marked *type* and designating it 'the holotype.' A specimen I have from Porto Rico, while a little darker in color pattern, seems to be identical and I am placing a compared with a type label on it.

"I think now that *C.* (*orixa*) *pygmaea* is also this species and that *wallengreni* and *blackburni* are also. They all have female pala shaped like the male somewhat."

Had this latter statement been entirely true, the name *reticulata* Guérin-Ménéville, 1857, would have fallen in favor of *pygmaea* Fieber, 1851; however, Lundblad, 1929,[1] published a redescription of Fieber's type in which he shows that *pygmaea* Fieber is a synonym of *verticalis* Fieber, the latter having page priority.

The problem was further complicated by Jaczewski (*24, p. 338*), who studied a specimen he obtained from the Paris Museum to which he refers as "co-type of *Corixa reticulata* Guérin, male from Cuba." This specimen he found to be identical with *Trichocorixa verticalis* (Fieber). If Jaczewski had designated the specimen that he studied the lectotype, it would then have been necessary to use *wallengreni* Stål, 1859, as the next available name. However, in view of Hungerford's notes, it is evident that Jaczewski did not study the specimen designated by Hungerford, in manuscript, as "holotype," but one which he mentions as "not the same species as the first male." Guérin-Ménéville's general description of *reticulata,* as well as the remark, ". . . mais elle en diffère par la forme réticulée des taches de ses élytres, surtout au delà du milieu, en arrière," in which he compares *reticulata* with *Corisa pygmaea* Fieber (now a synonym of *T. verticalis* [Fieber]), makes it clear that he was able to distinguish between these two forms. This evidence, supported by Hungerford's note concerning the identity of the specimen which bears the label "*Corixa reticulata* Guérin (type) Cuba male (or female)," makes it inadvisable to follow Jaczewski in placing *reticulata* as a synonym of *verticalis.* Had the entire type series been available to Jaczewski for study, it is probable that he would have arrived at a similar conclusion. It, therefore, seems proper to designate the specimen on which Hungerford placed the red label marked "type" as a lectotype. This definitely

[1] Arch. f. Hydrobiol. u. Planktonkunde **20**: 312-317.

fixes *reticulata* Guér. as the name for that species of *Trichocorixa* having the nodal suture dividing the pruinose area of the embolar groove into apical and basal portions, the width of the synthlipsis exceeding the width of an eye along the hind margin as seen from above, and the length of the pala usually less than two-thirds the width of an eye along the ventral margin.

T. reticulata is primarily coastal and insular in distribution, ranging along the east coast of the Americas from New Orleans, La., to Dutch Guiana and including the West Indies, and on the west coast from San Francisco, Calif., to Lima, Peru. In the Pacific it is known from the Galápagos Islands and from the Hawaiian Islands. Lundblad has also recorded the species from Shanghai, China (*12, p. 26*).

The following list of references pertains to *Trichocorixa reticulata* (Guérin-Méneville):

(1) *Corisa reticulata* Guérin-Méneville, 1857, *in* Sagra's Hist. de Cuba, **6**: 423. (Cuba.)

(2) *Corixa wallengreni* Stål, 1859, Kongl. Svenska Fregattens Eugenies Resa. Zool. **4**: 268. Stockholm. (San Francisco, Calif.). **New synonymy.**

(3) *Corixa blackburni* White, 1877, Ann. and Mag. Nat. Hist. **4**[20]: 114. (Hawaiian Islands.)

(4) *Corixa blackburni* White, 1878, Ann. and Mag. Nat. Hist. **5**[1]: 366.

(5) *Corisa reticulata,* Uhler, 1894, [London] Zool. Soc. Proc.: 224.

(6) *Corixa mariae* Champion, 1901, Biologia Centrali-Americana, Rhynchota-Heteroptera, **2**: 378. (Tres Marias Islands). **New synonymy.**[2]

(7) *Arctocorisa blackburni,* Kirkaldy, 1910, Fauna Hawaiiensis, **2**[6]: 554.

(8) *Arctocorisa blackburni,* Perkins, 1913, Fauna Hawaiiensis, **1**[6]: cciii.

(9) *Corixa reticulata,* Blatchley, 1926, Heterop. Eastern North America: 1084. (A synonym of *T. louisianae* Jacz.)

(10) *Trichocorixa mariae,* Jaczewski, 1927, Ann. Mus. Zool. Polon., Warszawa **6**[3]: 257.

(11) *Trichocorixa blackburni,* Hungerford, 1928, Brooklyn Ent. Soc. Bul. **23**: 174.

(12) *Trichocorixa wallengreni,* Lundblad, 1929, Ent. Tidskr. **50**[1]: 24-26, fig. 5, a-b; pl. IV, fig. 5. (Type material studied places *blackburni* as a synonym).

[2] The type of *Corixa mariae* Champion (*6, p. 378*) was studied by Hungerford at the British Museum in 1927, and in his notes he stated that it was "identical to the *reticulata* form." His sketch of the head and genital claspers confirms this view. Jaczewski, 1939 (*24, p. 183*), arrived at a similar conclusion, and placed *mariae* as a probable synonym of *wallengreni* Stål.

(13) *Trichocorixa reticulata,* Lundblad, 1929, Arch. f. Hydrobiol. u. Planktonkunde **20**: 317-320, figs. 23-27. (This treatment is a synonym of *T. naias* [Kirkaldy]).
(14) *Trichocorixa wallengreni,* Jaczewski, 1930, Mitt. aus dem Zool. Staatsinst. u. Zool. Mus. Hamburg **64**: 148.
(15) *Trichocorixa wallengreni,* Jaczewski, 1931, Ann. Mus. Zool. Polon., Warszawa **9** [15]: 214.
(16) *Trichocorixa mariae,* Jaczewski, 1931, Ann. Mus. Zool. Polon., Warszawa **9** [15]: 214. (Suggests that *mariae* is a synonym of *wallengreni*).
(17) *Trichocorixa reticulata,* Jaczewski, 1931, Arch. f. Hydrobiol. u. Planktonkunde **23**: 519. (A synonym of *T. naias* [Kirkaldy]).
(18) *Trichocorixa reticulata,* Lundblad, 1931, Zool. Anz. **96**[3-4]: 91. (Exclusive of citations other than Guérin-Méneville, 1857).
(19) *Trichocorixa reticulata,* Lundblad, 1931, Zool. Anz. **96**[3-4]: 90, 91, 93. (A synonym of *T. naias* [Kirkaldy]).
(20) *Trichocorixa mariae,* Lundblad, 1931, Zool. Anz. **96**[3-4]: 91, 93.
(21) *Trichocorixa wallengreni,* Lundblad, 1931, Zool. Anz. **96** [3-4]: 90, 91, 92.
(22) *Trichocorixa wallengreni,* Hutchinson, 1931, Amer. Nat. **65**: 573-574.
(23) *Trichocorixa wallengreni,* Jaczewski, 1933, Ann. Mus. Zool. Polon., Warszawa **9** [21]: 337.
(24) *Trichocorixa reticulata,* Jaczewski, 1933, Ann. Mus. Zool. Polon., Warszawa **9**[21]: 338.
(25) *Trichocorixa wallengreni,* Jaczewski, 1939, Ann. Mus. Zool. Polon., Warszawa **13** [23]: 284.
(26) *Arctocorixa blackburni,* Williams, 1944, Hawaii. Ent. Soc. Proc. **12** [1]: 195-196, fig. 16. (Excellent illustration of female; also valuable notes pertaining to habits).

Some New Species of Cerambycidae from the Island of Hawaii (Coleoptera)

By O. H. SWEZEY

(Presented at the meeting of September 10, 1945)

Plagithmysus davisi n. sp.

Head black, clothed with fine white pubescence; a distinct white crescent in the dorsal emargination of the eyes. Antennae dull red. Prothorax finely, densely punctured, very dark brown, almost black, with closely appressed fine white pubescence, except the naked longitudinal band including the dorsal crests. Anterior dorsal crest extended forward beyond margin of prothorax; posterior crest broadly rounded. Lateral crests distinct on posterior half of pronotum. Venter of thorax black with white pubescence; a large dense creamy patch of hairs on posterior part of mesopleura, a similar patch anteriorly. Legs dull red with thin white pubescence; apical fourth of femora black; hind tibiae and tarsi black. Elytra dull red, somewhat shining; somewhat transversely rugose on basal half; white pubescence arranged in numerous white flecks of various sizes and shapes, the larger ones along the suture and continuing to the tips of the elytra. Abdomen black with white pubescence. Length to tip of elytra 15-19 mm.

Allied to *vitticollis* and *swezeyi;* of larger size. The pronotum lacks the dense pronotal vittae. The flecks of white hairs on the elytra are much more numerous.

Described from three males collected by Mr. Clifton J. Davis, ranger at Hawaii National Park, from dead and dying trees of *Diospyros ferrea* at 2000 feet elevation in the vicinity of Puu Waawaa on the lower eastern slope of Mt. Hualalai, Hawaii, March 23, 1945. It is a pleasure to name this interesting new species for the collector, who is greatly interested in the insect faunas of the trees in the Hawaii National Park. (Later, 16 more specimens, both sexes, were reared from the same source.)

Holotype male in the collection of the Hawaiian Entomological Society. Paratypes in the collection of Experiment Station, H.S.P.A., and in the collection of the Hawaii National Park, and in the Bishop Museum.

Neoclytarlus dodonaeae n. sp.

Male 9 mm., female 14 mm. Black, with a clothing of appressed white pubescence on dorsum and also ventrally. Pronotum with a narrow median bare streak somewhat widened in the region of the anterior single transverse crest and in the region of the two posterior transverse crests; a wider similar bare streak towards each side, anteriorly and posteriorly situated on slight elevations; a considerable bare area on lateral area of pronotum, anteriorly a small bare spot between this and the dorsolateral bare streak. Elytra with the white clothing not divided transversely into areas of denser

clothing as in many of the species of *Neoclytarlus;* humeri with elevated rounded bare ridge extending backward somewhat obliquely towards the suture but not reaching it. The areas designated above as bare appear to be so, but are not entirely, being devoid of the white hairs, yet they have a few black hairs. Antennae darker than is usual in other species of *Neoclytarlus,* nearly black, with a few white hairs on the third and fourth segments. Legs sparsely clothed with white pubescence; femora of the usual *Neoclytarlus* type, the enlarged apical portion nearly black, slender portion of femora paler; posterior femora reaching about to 0.8 of elytra in female, nearer to apex of elytra in the male. The club of hind femur is proportionately slightly more thickened in the male than in the female.

Described from a male and female reared from *Dodonaea viscosa* var. *spathulata,* collected at 6400 feet elevation on the Mauna Loa truck trail, Hawaii, August 25, 1945, by Cilfton J. Davis, ranger in Hawaii National Park.

Holotype male and allotype female deposited in the type collection of the Hawaiian Entomological Society. Paratypes in collection of Experiment Station, H.S.P.A.

This is the twenty-seventh species of *Neoclytarlus* in Hawaii, eleven of which have been discovered and described since the publication of the Fauna Hawaiiensis.

Later note: Four more specimens issued October 1-6 from a section of partially dead trunk of *Dodonaea* collected at the place mentioned above and sent to me by Mr. Davis. Also, Mr. Davis reared eight beetles Oct. 20 to 27 from *Dodonaea* from the same locality, and contributes the following notes on the distribution of this species of *Neoclytarlus:*

"Highest elevation found—6400 ft. (original discovery) on both sides of Mauna Loa truck trail.

"Lowest elevation found—4500 ft. near Maunaiu water tanks, Ohaikea.

"Optimum range—4900 to 6400 ft. elevation. This is quite obvious as one finds numerous signs of it in this range.

"With the exception of 6400 ft., it is found in isolated kipukas down to 4500 ft. on the west side of the Mauna Loa truck trail.

"Host range—The host plant is abundant and widespread throughout the Park from 8000 to 1500 ft. The optimum development of the hostplant appears to occur between 5000 and 5500 ft. Here these trees attain the height of between 25 to 30 feet and a diameter of 6 to 8 inches.

"I have not found the beetle or signs of it from 6500 to 8000 ft. Nor have I found it in the southern portion of the Park, from Kipuka Nene to Hilina Pali (3000 to 2000 ft.) nor in the Pohiokeawe region through the lands of Keauhou, Kahue, Apua, and a portion of Kealakomo."

Neoclytarlus mezoneuri n. sp.

Female. Black, with a sparse clothing of white appressed setae on head, prothorax, elytra, also ventrally, having no pattern of arrangement into denser patches or streaks as is usually the case in related species of *Neoclytarlus*. Antennae dark brown, with the apices of some segments blackish. Prothorax and elytra dull, densely rugosely punctured. Prothorax with the usual median transverse crests: a large single one anteriorly, and two smaller ones posteriorly. Legs with the club of femora black or dark brown; the slender portion of femora, tibiae and tarsi paler. Posterior femora extend a little beyond the tips of the elytra. Length to tip of elytra 8 mm.

Described from a single female which Mr. Davis reared November 11, 1945, from wood of *Mezoneurum kauaiense* collected by A. L. Mitchell in the Puu Waawaa region, on the northeast slope of Mt. Hualalai, Hawaii.

Holotype in the type collection of the Hawaiian Entomological Society.

New Species of Hawaiian Lepidoptera

By O. H. SWEZEY

(Presented at the meeting of December 10, 1945)

Herewith are presented the descriptions of a number of new species of Hawaiian moths which have been reared from time to time or otherwise discovered in working over collections, and set aside for the time being awaiting description (on account of there being but a single specimen, or because the material at hand was not in perfect enough condition) in the hope that more and better material might yet be obtained from which to make descriptions. However, it seems best now to put some of these on record without further waiting.

The family names used for the Microlepidoptera herein are as adopted by Mr. August Busck in a revision of Hawaiian Microlepidoptera which he had under way at the time of his demise.

The types are in the type collection of the Hawaiian Entomological Society.

Family Pyraustidae

Phlyctaenia campylotheca n. sp.

Male, female. 16-20 mm. Head, palpi, antennae and thorax ferruginous; palpi 3-3½, white beneath at base. Abdomen slightly paler ferruginous, anal tuft of male ochreous, ferruginous at base. Forewings ochreous ferruginous, varying in the intensity of the ferruginous tint; round orbicular and eight-shaped discal spots outlined with fuscous, obscure in the specimens with most intensely ferruginous-tinted wings, in which also the first and second lines are obscure; in specimens with less intensely ferruginous wings the lines are fuscous and of the usual form for *Phlyctaenia;* a terminal series of very small dots; cilia fuscous, white tipped. Hindwings light fuscous, darker terminally; two obliquely placed darker discal dots, often obscure; postmedian line obsolete, or occasionally indicated; a terminal series of minute fuscous dots, often obscure; cilia whitish with basal half fuscous, or sometimes nearly entirely fuscous.

The most intensely ferruginous specimens which were assembled by Meyrick in *despecta,* which he treated of as a very variable species, I would place in *campylotheca,* named for the food plant from which all of my specimens were reared. Formerly *Campylotheca* included a large number of Hawaiian species of plants which are now recognized as *Bidens* by the botanists.

Reared from foliage of *Bidens* (*Campylotheca*), Palolo Valley, Oahu, October 6, 1906, December 13, 1908; Niu ridge, Oahu; November 11, 1906; Mt. Olympus, Oahu, January 21, 1912 (Swezey); Mt. Konahuanui, Oahu, July 23, 1916 (Timberlake); Kumuweia,

Kauai, August 28, 1921 (Swezey); Haleauau Valley, Oahu, January 16, 1932 (Swezey).

Phlyctaenia phyllostegia n. sp.

Male. 19 mm. Head, palpi, antennae and thorax pale brownish ochreous; antennae whitish beneath, palpi 3½, white beneath. Abdomen ochreous, with apical segmental margins white, anal tuft white. Legs ochreous, anterior tibiae dark fuscous basally, middle tibiae with fuscous longitudinal line above, tarsi somewhat infuscated. Forewings pale brownish ochreous; costa with four fuscous spots on apical half; roundish orbicular and discal spots outlined with fuscous, the discal larger; first line wavy, indicated by fuscous scales, extending nearly vertically from orbicular to dorsum; second line wavy, indicated by fuscous scales vertically from second fuscous costal spot to vein three, then a wide loop extends basally to below discal spot then about parallel to dorsum terminating about midway between first line and tornus; eight conspicuous fuscous terminal spots between veins; cilia concolorous. Hindwing pale brownish ochreous, darker on the apical third; two obliquely placed fuscous discal dots; an obscure fuscous postmedian line from a fuscous dot on costa; a terminal series of fuscous dots; cilia somewhat paler than terminal area of wing.

This species has considerable resemblance to *Pyrausta thermantis* Meyr. in which however, the forewing is ferruginous, the loop of second line beneath discal spot is narrower, and the terminal dots are smaller.

A single specimen reared from leaves of *Phyllostegia* sp., Pacific Heights ridge, Oahu, March 3, 1912 (Swezey).

Family Tortricidae

Tortrix lysimachiana n. sp.

Female. 16 mm. Head and thorax brownish fuscous. Palpi brownish fuscous about 3, middle joint long, terminal joint very short. Antennae brown, about ⅔. Forewings brownish fuscous, a series of darker spots on costal and dorsal margins; a medium wide irregular-margined darker band extends outwardly oblique from ⅓ of costa to the fold, the margins are indicated by a few black scales outside of which a pale line; a few scrawly black marks in outer part of wing; cilia pale, barred with fuscous. Hindwings pale gray, darker terminally and with scattered slightly fuscous spots which are more conspicuous on the under surface; cilia pale, fuscous on basal half. Abdomen ochreous. Fore and middle legs brown, tarsi spotted with ochreous. Hindlegs ochreous, tarsi spotted with fuscous.

Described from a single specimen reared from foliage of *Lysimachia rotundifolia*, Puu Hapapa, Waianae Mts., Oahu, January 16, 1927 (Swezey).

Epagoge osteomelesana n. sp.

Female. 9 mm. Head and thorax pale fuscous, the scales tipped with white. Head rough scaled; palpi 2, second segment rough scaled, whitish, terminal segment short, black. Antennae fuscous, about ½. Forewings white with numerous fuscous strigulae; costa with a series of dark fuscous spots, those on basal half small, on the apical half larger and from three or four of them are outwardly-oblique bars, the one from middle of costa connected with a longitudinal fuscous streak in outer portion of cell; at apex is a larger dark fuscous costal spot with a tapering extension dorsally to about middle of

termen, between this dark spot and the cell is a white area almost free of strigulae, but with some fuscous scales on its dorsal side, most distinct anteriorly. Cilia white and fuscous mixed. Hindwings nearly uniformly pale brownish, slightly darker terminally, and without markings; cilia gray, whitish mixed towards apex. Legs whitish, fore and middle tibia and all tarsi fuscous marked. Abdomen very pale brownish.

A single specimen reared from *Osteomeles anthyllidifolia*, Woodlawn, Manoa Valley, Oahu, November 18, 1929 (Williams).

Family Cosmopterygidae

Petrochroa communis n. sp.

Male, female. Expanse 9-10 mm. Head and thorax white, some of the scales tipped with black. Palpi white, externally spotted with black, second segment black at apex, terminal segment black-tipped. Antennae black, basal joint white speckled with black, with pecten ventrally, flagellum in male slightly serrated. Fore and middle legs fuscous, hind legs mostly whitish. Abdomen dirty white, ringed with fuscous, anal tuft of male creamy white. Forewings white with many of the scales tipped with black giving a gray appearance, an elongate black spot occupying about the middle fifth of the fold, two or three scattered similar spots between the spot in the fold and the costa, sometimes a black streak between the cell and the termen; cilia gray, two black spots in costal cilia just before apex. Hindwings nearly uniformly gray, cilia pale gray. The venation varies somewhat from that of the genotype in that vein 6 of forewings is sometimes separate from 7 + 8; also in the hindwings 6 is usually separate from 7; frenulum in female consisting of 4 spines.

Taken at light, Kaimuki, Oahu, various times, 1908 to 1915 (Swezey); and Kokee, Kauai, August 29, 1921 (Swezey). Taken commonly in light traps at several locations in the Pearl Harbor region, Kaneohe, and in Honolulu, Oahu, 1944 and 1945.

Family Caloptiliidae

Parectopa lipochaetae n. sp.

Male, female. 5-6 mm. Head white; palpi white, second segment with a black dot at apex, third segment with a black dot near tip; antennae white beneath, ringed with fuscous above. Thorax white. Abdomen whitish, anal tuft of male white. Legs white, forelegs and middle legs and posterior tarsi spotted with black. Forewings with ground color pale fawn, but appearing mostly white on account of the white streaks arranged as follows: three costal very outwardly-oblique and two dorsal which join the first and second costal in middle of wing; the two dorsal streaks are wide at base, the first one following dorsal margin to base of wing, the wide base of the second dorsal extends nearly to the tornus; the third costal streak reaches about half or a little more across the wing, straight and not quite parallel with the second costal streak; sometimes a white median streak in basal portion of wing; three short white streaks on costa near apex; a round black spot situated in terminal white area; all white streaks bordered by black scales and a line of black scales on termen at base of cilia. Cilia white, outer half fuscous. Hindwings and cilia slightly infuscated.

In its markings near related to *marginestrigata*. Reared from leafminer in *Lipochaeta lavarum*, Lahaina, Maui, December 23, 1928 (Swezey).

Parectopa nigrelloides n. sp.

Male (?). 8 mm. Head and thorax brownish fuscous; palpi white above, blackish beneath; antennae black. Thorax and abdomen white below. Legs pale brownish, tarsi spotted with white. Forewing bronzy brown; an outwardly oblique white bar from ¾ of costa, extending about ⅔ across wing; a few white scales on dorsum near base; at ⅝ of dorsum an outwardly oblique white streak extends to about middle of wing, wider at base and tapering to a point; a smaller white streak at ⅔ of dorsum; in terminal area of wing a blue spot with black center; near apex of costa three spots, the first one larger, separated by black spots; cilia concolorous with the white and black spots; terminal cilia fuscous, pale at base where they join a line of black scales marking the terminal border, tornal cilia fuscous.

A single specimen reared from mine in leaf of *Dubautia* sp., Alakai Swamp, 4,000 ft., Kauai, August 22, 1921 (Swezey). Resembles *Philodoria nigrella* Walsm. from Kilauea, Hawaii; but it has maxillary palpi, which are absent in the genus *Philodoria*.

Synonymic Notes on Argyroploce illepida (Butler) and A. carpohaga (Walsingham) (Lepidoptera: Eucosmidae)

By O. H. SWEZEY and ELWOOD C. ZIMMERMAN

(Presented at the meeting of September 10, 1945)

A. Notes by O. H. Swezey

This eucosmid moth, known in Hawaii as the koa seed moth on account of the heavy infestation of koa seeds by its larvae, was described by Butler as *Teras illepida.* The description is from a single specimen collected by the Rev. Thomas Blackburn: "In neighborhood of Honolulu; rare.—T.B." In the description the sex is not stated, but it more nearly agrees with the male as we know it at the present time.

Walsingham (Fauna Hawaiiensis, 1 [5] : 681, 1907) placed the species in the genus *Cryptophlebia* which he had erected for *carpophaga,* a species described from India (Indian Museum Notes 4: 105, 1899). Apparently the genus is named for a character in the hindwing of the male: "A pouch-like fold along vein 2, containing a thick tuft of scales on the upper side, accompanied by some strongly curved scales on the underside along the margin." This character is common to both *illepida* and *carpophaga.*

Then Meyrick (Records of the Indian Museum, 5: 218, 1910) removed *illepida* to the genus *Argyroploce* and placed *carpophaga* as a synonym of *illepida,* the latter having priority of publication. It would seem that the character on which the genus *Cryptophlebia* was based was sufficient to maintain it as a good genus. This character is not used in the description of the genus *Argyroploce,* a genus of over 500 species. However, in this large genus Meyrick has described a large number from many regions, and among them quite a number have various kinds of secondary characters in the hindwings of the males. It would necessitate many more genera if each of these various characters were used as a basis for separate genera. Hence, no doubt Meyrick is fully warranted in placing *illepida* and *carpophaga* in *Argyroploce,* instead of leaving them in an isolated genus. Fletcher has also adopted this usage (Some South Indian Insects, p. 449, 1914).

When in Guam in 1936, I reared a good series of moths from the seeds of several leguminous trees, which agree with Walsingham's description and figure of *carpophaga,* and I noted differences between these specimens and those reared in Hawaii from seeds of *Acacia koa, Acacia farnesiana* and several other leguminous trees,

but not from *Poinciana regia, Adenanthera pavonina* and *Pithecolobium dulce* all of which had their seeds badly infested by *carpophaga* in Guam. Hence, I must take exception to Meyrick's synonymy, and consider the two as different species, irrespective of the fact that he states: "Having obtained a series of the Hawaiian from [*illepida*], I find it is identical with Australian, Indian and South African examples [*ombrodelta* and *carpophaga*]."

Some of the differences are as follows: The male of *carpophaga* has much more long woolly hair on dorsum of abdomen; the large tufts on posterior tibia and enlarged basal joint of tarsus are blackish, whereas in *illepida* they are ochreous; the dorsal portion of forewing beneath the fold is infuscated and with a slight admixture of bone-grey scales in *carpophaga,* but not so in *illepida;* in forewing a triangular dark spot near the tornus having its base on dorsum in *carpophaga,* absent in *illepida;* cilia of hindwing white in *illepida,* grey in *carpophaga.* There are 24 males in my Guam series, which I have compared with a series of 40 *illepida* males. The females do not exhibit such striking differences. In both species the forewings vary in the degree of coloration: tawny, ferruginous or brown, but both have the triangular darker spot near the tornus.

So far as known to me, *illepida* does not occur anywhere except in the Hawaiian Islands, and any records in literature of its occurrence elsewhere, no doubt should be considered as belonging to the true *carpophaga.*

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Cryptophlebia illepida, Walsingham, Fauna Hawaiiensis, **1** (5): 681, pl. X, 23-25, 1907.

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Argyroploce illepida, Fletcher, Some South Indian Insects: 449, 1914.

B. Notes by E. C. Zimmerman

In the foregoing note, Dr. Swezey has outlined his reasons for believing that the moth *Argyroploce illepida* (Butler) of Hawaii is distinct from the widespread *A. carpophaga* (Walsingham). His conclusions are based upon studies of the food habits and external features of the moths. He has asked me to make a study of the genitalia of the species, and I am glad to report that the results of the examination of the male genitalia fully support his conclusions.

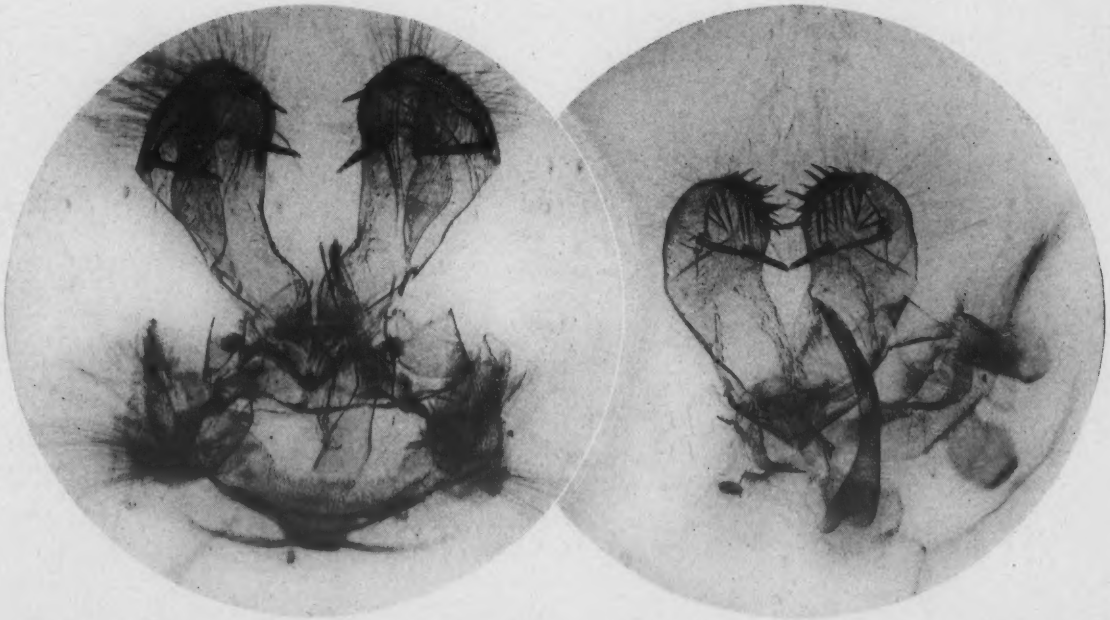

Figure 1.—Left: Photograph of a balsam mount of the genitalia of a male *Argyroploce carpophaga* (Walsingham) collected at light at Piti, Guam, July 12, 1936, by O. H. Swezey. Right: Photograph of a balsam mount of the genitalia of a male *Argyroploce illepida* (Butler) collected at Kaimuki, Oahu, T. H., April 17, 1908, by O. H. Swezey.

Herewith are presented reproductions of photographs (kindly made for us by Mr. D. M. Weller, histologist at the H.S.P.A. Experiment Station) which show, without the need of further explanation, how easily the two species may be distinguished on the basis of the male genitalia alone. There is no question that *Argyroploce illepida* is fully distinct from *A. carpophaga.*

An additional problem which we have considered is the status of the two varieties of *Argyroploce illepida* and the two separate species described by Walsingham from Hawaii.

In the series of this common moth (*illepida*) before us, there is a great range of size (12 to nearly 25 mm.), color and color pattern. Slides of the male genitalia of 10 examples from different places, collected free or reared from *Acacia confusa, Acacia koa, Pithecolobium, Dodonaea* and *Sapindus,* and mostly showing differences in color pattern, have been examined. In spite of size and color differences, the structure of the genitalia of all specimens studied is remarkably uniform.

It is of interest to note that Walsingham had 15 examples of his *illepida fulva,* only one of *illepida suffusa,* two damaged *tetrao* and a unique of *vulpes.* If one wished to describe color variations, a number of new ones could be erected from the variable series now available. Perhaps Walsingham would not have proposed so many names if he had been supplied with a more representative series of examples and if he had been more acquainted with the bionomics of the species.

From the evidence now at hand, it appears that there is only one species of *Argyroploce* in Hawaii, and the following synonymy is indicated:

Argyroploce illepida (Butler)

Teras illepida Butler, Trans. Ent. Soc. London, p. 42, 1882.

Cryptophlebia illepida illepida (Butler) Walsingham, Fauna Hawaiiensis, 1 (5) : 681, pl. 10, fig. 23, 1907.

Cryptophlebia illepida var. *fulva* Walsingham, loc. cit., pl. 10, fig. 24. New synonym.

Cryptophlebia illepida var. *suffusa* Walsingham, op. cit., p. 682, pl. 10, fig. 25. New synonym.

Cryptophlebia tetrao Walsingham, op. cit., p. 683, pl. 10, fig. 26. New synonym.

Cryptophlebia vulpes Walsingham, loc. cit., pl. 10, fig. 27. New synonym.

Argyroploce illepida (Walsingham) Meyrick, Records Indian Museum, 5 : 218, 1910.

Notes and Descriptions of Ceratocombus (Hemiptera: Cryptostemmatidae)

By ROBERT L. USINGER
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(Presented at the meeting of December 10, 1945)

Several interesting cryptostemmatids have come to hand during the past two years, both from my own collecting and from material submitted for identification. The new records and species of *Cryptostemma* have been described elsewhere (Usinger, Ent. News, **56**: 238-241, 1945). In the present paper a new record is given for *Ceratocombus vagans* McAtee and Malloch, and new species of *Ceratocombus* are described from Puerto Rico and Hawaii. I am indebted to E. C. Zimmerman and R. I. Sailer for the opportunity to study the Hawaiian specimens. These are of particular interest because they represent the first collection of Cryptostemmatidae from the Hawaiian Islands.

Ceratocombus (Xylonannus) vagans McAtee and Malloch, 1925

This species was originally described from Maryland with paratypes from Washington, D.C., Virginia, New York, Florida and Panama. Barber (1939)* reported it from Puerto Rico. Uhler's *niger* (1904) from New Mexico was doubtfully referred here by McAtee and Malloch and they suggested that Champion's *panamensis* (1900) may prove to be the same when the type is studied in this connection. I am now able to add Georgia to the list and record another locality for Puerto Rico.

One macropterous female and numerous nymphs were taken amidst loose frass beneath the bark of a decaying tree near the summit of Brasstown Bald (approximately 4500 feet elev.), Georgia, Sept. 10, 1944 (R. L. Usinger).

Both macropterous and brachypterous specimens were very abundant on the ground beneath leaf mold and numerous small fruits of a fallen Sierra palm near the summit of El Yunque, Puerto Rico, April 29, 1945 (R. L. Usinger).

Ceratocombus (Xylonannus) hawaiiensis Usinger, new species

Suboval in form and rather uniformly brownish to castaneous in color.

Head one-third broader, eyes included, than long, 12::9. Eyes one-fourth as wide as interocular space, 2::8. Vertex smooth, moderately convex.

* Dates in parentheses refer to the bibliography at the end of the paper. [Ed.].

Clypeus broad, parallel-sided and slightly inflated. Rostrum surpassing posterior coxae, the proportion of segments 2: 9½: 7½. Antennal proportions 2: 5½: 9: 9.

Pronotum over twice as broad across humeral angles as long on median line, 17:: 8, and slightly shorter than head, 8:: 9. Disk only moderately convex, smooth, the anterior collar marked by a transverse impression laterally behind eyes, briefly transversely foveate anteriorly at middle. Lateral margins feebly rounded, sinuate at anterior constriction. Posterior margin broadly, deeply concave.

Scutellum broader than long, 9:: 7, subflattened and impressed with two minute foveae near middle; sides nearly straight to acute apex.

Hemelytra presumably complete, the distance from tip of clavus to apex of membrane greater than distance from base of corium to tip of clavus, 16:: 14. Venation as in *vagans* McAtee and Malloch, but with the two apical cells equal in size.

Under surface as in *vagans*, the male genitalia agreeing with the illustrations of McAtee and Malloch and with Puerto Rican specimens of *vagans*.

Color uniformly pale brown, the hemelytra translucent, the eyes reddish, anterior portion of head and appendages pale. Under surface brown to ochraceous.

Size: Length 1.3 mm., width (pronotum) 0.5 mm. (hemelytra) 0.62 mm.

Holotype, macropterous female, Waipahee, Kauai, T. H. Jan. 13, 1944, under bark of dead tree (N. L. H. Krauss). Allotype, male, and one female paratype, macropterous, same data as type. The holotype and allotype are deposited in B. P. Bishop Museum, Honolulu, T. H.

Hawaiiensis is similar to *vagans* in every way except for the form and proportions of the head and pronotum. These proportions differ strikingly in the two forms of *vagans* as follows: brachypterous form—head scarcely broader than long, 11:: 10; eyes small, one-fourth as wide as interocular space, 2:: 8; pronotum strongly convex, nearly parallel-sided, less than twice as broad as long; macropterous form—head distinctly broader than long, 10½:: 8; eyes larger, nearly half as wide as interocular space, 2½:: 6; pronotum twice as broad as long, 14:: 7.

In *hawaiiensis* the eyes are small as in brachypterous *vagans* while the head is relatively broad as in macropterous *vagans*. The pronotum is even wider than in macropterous *vagans* and has convex side margins in contrast to concave margins in *vagans*. In general appearance the head of *hawaiiensis* is more robust and less strongly narrowed in front of the eyes and the pronotum is broad with sides convex. These characteristics served to distinguish *hawaiiensis* from the long series of specimens of *vagans* which I studied in the U. S. National Museum collection.

Ceratocombus (Ceratocombus) yunquensis Usinger, new species

Elongate-oval, attenuated anteriorly, the surface above opaque, black, distinctly marked with a yellow longitudinal fascia on inner half of each corium, these fasciae almost or quite joining an arcuate fascia which crosses apices

of coria and base of membrane. Hairs on upper surface, except head, very short and sparse, confined to margins and to veins of hemelytra.

Head broader than long, 12::9; the eyes, seen from above, about one-third as wide as interocular space, 2½::7; eyes touching anterolateral angles of pronotum; ocelli contiguous with inner margins of eyes; surface smooth, impunctate, naked and slightly convex basally; transversely wrinkled and beset with long, curved hairs apically. A long bristle behind each ocellus and another near front of eyes. Rostrum reaching to middle of intermediate coxae, the proportion of segments 3:8:7. Antennae as long as head, pronotum, and scutellum together, the proportion of segments as 2½:5:10:9.

Pronotum over twice as broad behind as long on median line, 18::8, and slightly shorter than head, 8::9½; anterior collar obscure except near depressed anterolateral angles, lateral margins straight, with a prominent, anterolaterally directed bristle at anterior fourth; front margin slightly concave, hind margin broadly concave.

Scutellum broader at base than long, 12::9, feebly convex, the sides sinuate, subacute at apex.

Hemelytra complete, very long and broadened apically, the membrane almost as long as corial margin and four-fifths as wide. Corial margin scarcely arcuate, the disk subflattened laterally, convex on inner two-thirds, apex narrowly deflected beyond brief fracture. Venation as figured by McAtee and Malloch for *areolatus* except that the outer vein emanating from discal cell does not curve outward toward cuneal fracture but continues straight to wing margin.

Color dull to glossy black above with ochraceous anterior two-thirds of head, a bright yellow fascia arising at base of corium and continuing along inner corium, occupying the greater part of inner corium between emboliar and claval sutures. The yellow extends to embolium and outer clavus at extreme base. Apically the fascia narrows abruptly or is briefly interrupted before transverse apical fascia. The latter arises at and just beyond subapical fracture. It does not reach apex of corium at lateral margin but extends broadly inward and crosses apical margin of corium on inner half, thence continuing across base of membrane. Membrane pale smoky white along outer margin. Rostrum and first two antennal segments pale, apical antennal segments brown. Under surface of head reddish-ochraceous, elsewhere brownish with pale pubescence, the legs pale with brown at middle of coxae and femora.

Size: Length 1.7 mm., width (pronotum) 0.52 mm. (hemelytra) 0.8 mm.

Holotype, female, and two female paratypes, Sierra palm forest, El Yunque, Puerto Rico, April 29, 1945 (R. L. Usinger). These specimens were taken beneath leaf mold and numerous small fruits of a fallen Sierra palm in company with the much more abundant *Ceratocombus vagans*. The holotype is deposited in the U. S. National Museum.

Yunquensis is closely related to *fasciatus* Uhler from Grenada and St. Vincent, but differs from that species in hemelytral markings and in its larger size. It runs to *brasiliensis* Reuter in McAtee and Malloch's key, but that species lacks the distinctive yellow fasciae. *Bifenestratus* Poppius (1910) from the island of Guadeloupe also belongs near here but lacks the distinctive markings of *yunquensis*.

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Psychoda pseudalternata n. sp. (Diptera: Psychodidae)

By FRANCIS X. WILLIAMS
Experiment Station, H.S.P.A.

(Presented at the meeting of June 11, 1945)

Some years ago the B. P. Bishop Museum, Honolulu, sent to Dr. A. L. Tonnoir a number of *Psychoda* flies for determination. Dr. Tonnoir died before completing his work; he did, however, recognize a new species in the collection, specimens of which he had recently collected in Canberra, Australia. This species he named *Psychoda pseudalternata* and he returned specimens so labelled as paratypes, to the Bishop Museum, as well as including specimens of the same species taken at Canberra.

Since Dr. Tonnoir, as far as can be ascertained, has not published a description of this insect, it rests upon myself to give further data upon it. I figured (Proc. Haw. Ent. Soc., **11**: 336, 1943) the male terminalia of *Psychoda pseudalternata*, as well as of *Psychoda alternata* Say (l.c.: 334), both from specimens determined by Dr. Tonnoir. I can only state that *Psychoda pseudalternata* is close to *P. alternata*, but the former has the spinule of the inferior appendage of the terminalia broadened, subspatulate towards the apex and the margin oblique there, while in *P. alternata* this spinule is only moderately widened but somewhat curved apically. There are no specimens of *Psychoda alternata* females determined by Dr. Tonnoir in the collections here.

The specimen now designated as lectotype bears the label *Psychoda pseudalternata* ♂ paratype Tonn., Canberra, A. C. T., April 1939. A. L. Tonnoir. A ♀ syntype bears the same data. Other syntypes (paratypes) are: One ♀, Manoa Valley, Honolulu, Feb. 3, 1934, at light (Carl T. Schmidt); one ♀ and one partly dissected specimen, Honolulu, Oahu, March 25, 1923, Quarantine Island (S. C. Ball), glued on a card with other specimens but set off from these by an ink-lined square. The lectotype and all the syntypes are in the collection of the B. P. Bishop Museum.

I am indebted to Dr. Alan Stone of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, U. S. Dept. Agriculture, for calling my attention to the status of this insect.

Stigmatomma (Fulakora) zwaluwenburgi, a New Species of Ponerine Ant from Hawaii

By FRANCIS X. WILLIAMS
Experiment Station, H.S.P.A.

(Presented at the meeting of September 10, 1945)

In February 1941, Mr. R. H. Van Zwaluwenburg discovered four workers of this ant while searching for tiny hypogaeic carabid beetles in soil obtained from a field of sugar cane at the Experiment Station, H.S.P.A., Honolulu. A fifth specimen (the paratype) was taken by the writer on October 26, 1945 in moist soil from the same field.

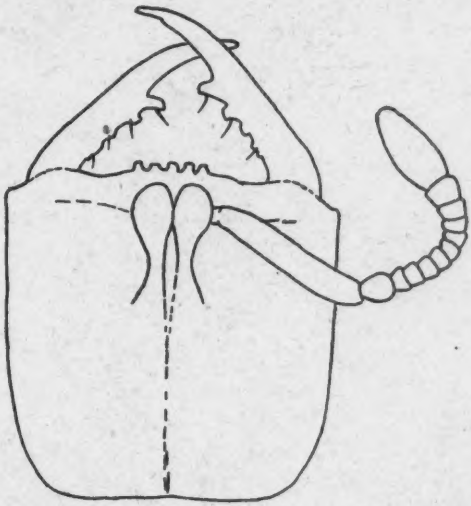


Figure 1.—*Stigmatomma* (*Fulakora*) *zwaluwenburgi*, type.

Stigmatomma (Fulakora) zwaluwenburgi n. sp.

Type: Length 1.80 mm. Head as broad at clypeus as long; occiput shallowly concave; fronto-occipital suture not strong; clypeus in front armed with five rather blunt denticles. Mandibles with the thickened basal portion bearing five simple teeth, the basal one quite small; one subapical denticle. Frontal lobes touching rather narrowly, their carinae feeble and diverging behind. First and apical funicular joints longer than broad. Eyes wanting. Thoracic dorsum and epinotum flat. Prothorax a little longer than broad,

gently rounded. Promesonotal suture strongly impressed. Mesonotum more than twice as broad as long, the sides nearly straight. Mesoëpinotal suture indistinct. Epinotum gradually widening from base, about as broad as long to ventral apex, the declivity transverse, generally smooth, the sides strongly margined. Petiole narrower than first gastric segment, rounded in front and more slightly so at the sides. Gaster slender, legs stout.

Head and thorax sublucid, epinotum and gaster more shining. Mandibles with some rugae. Head and thorax densely granulose, thoracic dorsum and epinotum with some subobsolete carinulae, gaster with more separate punctures.

Color rufo-testaceous, the head a little darker; pilosity whitish.

The paratype is approximately 1.75 mm. long from the apical part of the clypeus; there are four somewhat recurved teeth on the inner side of the mandibles, the basal teeth being short. The clypeus has the five bluntly conical teeth on its margin.

Type and paratype in the collection of the Hawaiian Entomological Society.

Three of the five specimens collected are not now available.

The subgenus *Fulakora* was erected by Mann for *Stigmatomma* (*Fulakora*) *celata* from the British Solomon Islands. It—"is proposed for those species of *Stigmatomma* that have the frontal lobes approximate, instead of widely separated." (The Ants of the British Solomon Islands. Bul. Mus. Comp. Zool., **63** [7] : 279-280, 1919).

This subgenus has representatives in Australia, New Zealand, Sumatra, Philippines, Hawaii, Cuba, Brazil, Argentina, and no doubt elsewhere.

S. (*Fulakora*) *zwaluwenburgi* differs from its apparently nearest relatives, *S.* (*Fulakora*) *celata* Mann from the British Solomon Islands and *S.* (*Fulakora*) *minuta* Forel from Sumatra (Zool. Jahrb. systematik, **36** : 4-5, 1914) chiefly in having the head quite as broad as long and in having the clypeus provided in front with five teeth, *Stigmatomma* (*Fulakora*) *celata* and *minuta* each having six teeth.

I take pleasure in naming this species after my colleague, Mr. R. H. Van Zwaluwenburg.

It is presumed that this ant is one of the relics of an earlier Hawaiian ant fauna of which our representatives are chiefly minute ponerines and which may have survived under unfavorable environment because of their hypogaeic habits. (See Wheeler: Revised List of Hawaiian Ants., Bernice P. Bishop Museum, Occasional Papers **10** [21] : 5, 1934).

Two New Species of Astatinae, with Notes on the Habits of the Group (Hymenoptera: Sphecidae)

By FRANCIS X. WILLIAMS
Experiment Station, H.S.P.A.

(Presented at the meeting of December 8, 1945)

Astata immigrans n. sp. (plates XXXI-XXXIII figures 1-13)

Female, holotype: Length 5.5 mm. Of the usual stout form. Black; mandibles testaceous mesad, reddish apically; veins at base of wings and a prestigmatal spot creamy white, remaining venation of fore wings more or less testaceous, venation of secondaries much paler; tibiae, more or less, and tarsi brownish; tegulae and sclerite at costal base of fore wings dark brownish, wings hyaline, abdomen red. Head and thorax generally, very finely coriaceo-reticulate, subopaque. Mandibles bidentate, with a few punctures outwardly at base, malar space very short; clypeus with the disc gently convex, with a few large punctures, the margin depressed, narrowly produced mesad into two rounded teeth with a low lobe on either side; antennae with joint 3 considerably longer than 4, 4 slightly longer than 5, the interocular space at vertex being slightly greater than joints 3 plus 4; ocelli arranged nearly in an equilateral triangle, the anterior ocellus very slightly the farthest removed; a small scar that narrows anteriorly, borders the inner margin of the eyes opposite each posterior ocellus; a fine impressed line from anterior ocellus extending more than half way to the base of the clypeus; a few scattered punctures on frons and vertex. Anterior portion of pronotum smooth and shining, scutellum more shining in its anterior portion, metanotum shining, almost smooth; disc of propodeum finely margined, very finely reticulate, although the sculpture is not as fine as that of the thorax proper; there is a delicate carinula at the base and a large shallow subtriangular depression at the apex, the pleura with some fine oblique striae, the posterior face is steep, largely smooth and shining mesad with an oval fovea above. First joint of fore tarsus with a comb of four bristles, the apical bristle the heaviest, and each bristle about twice as long as the diameter of the joint; fore and posterior femora with some long erect hairs beneath. Forewings with the marginal cell very short, only a little longer than high and shorter than the stigma, the poststigmatal part about as long as the substigmatal part; second submarginal cell sessile at the marginal cell, its basal or 1st t.c. border with a stub of a vein mesad; third submarginal cell very short, nearly twice as high as long, the long sides subparallel. Pygidium with the marginal carinae and hair fringe indicated only at apex. Vestifure of sparse pale hair.

Male, allotype: Length 5.5 mm. Head and thorax black, abdomen red darkening apically. Pale markings as follows: mandibles widely creamy yellow mesad, a large squarish spot each side before declivity of face, prothoracic lobes, tegulae and veins at base of wings creamy white; apex of femora quite narrowly, (and obscurely in the posterior femora) and the fore tibiae and tarsi generally, pale yellowish to yellowish brown, base and apex of tibiae 2 and 3 less obviously pale. Mandibles bidentate at apex and a low wide tooth on inner margin at base of second apical tooth, malar space not twice as wide as long; clypeus triangularly produced, the apex somewhat attenuated; antennae showing only very slight swellings latero-ventrad at base of 7, 8 and 9. The sculpture is less fine than in the female, the pleura are sprinkled pimple-like with fine granulations; the sides of the propodeum are

not striate, the posterior face is shining with scattered granulae, and the fossa is somewhat more developed than in the female. Pygidial area with a few large punctures; terminalia shown in fig. 11. Vestiture moderate, of erect silvery hair.

Holotype: Oahu: Honolulu, at Experiment Station, H.S.P.A., May 24, 1943; on *Portulaca oleracea* Linn. (F. X. Williams). *Allotype:* Oahu: Ewa, July 18, 1939, on *Portulaca oleracea.* (F. X. Williams). *Paratypes:* Ewa, Oahu, 3 ♀ ♀, August 3 and 4, 1939, 2 ♂ ♂, July 18, 1939; Honolulu, Oahu, 1 ♂ and 1 ♀, June 19, 1942, 1 ♀ and 4 ♂ ♂, late May, 1943, and 4 ♀ ♀ and 2 ♂ ♂, June, 1943 (reared).

This small species is related to *Astata bella* Cresson (Trans. Am. Ent. Soc. [Proc.] **9**: vi, 1881 ♂ "Hab.-San Diego, California").

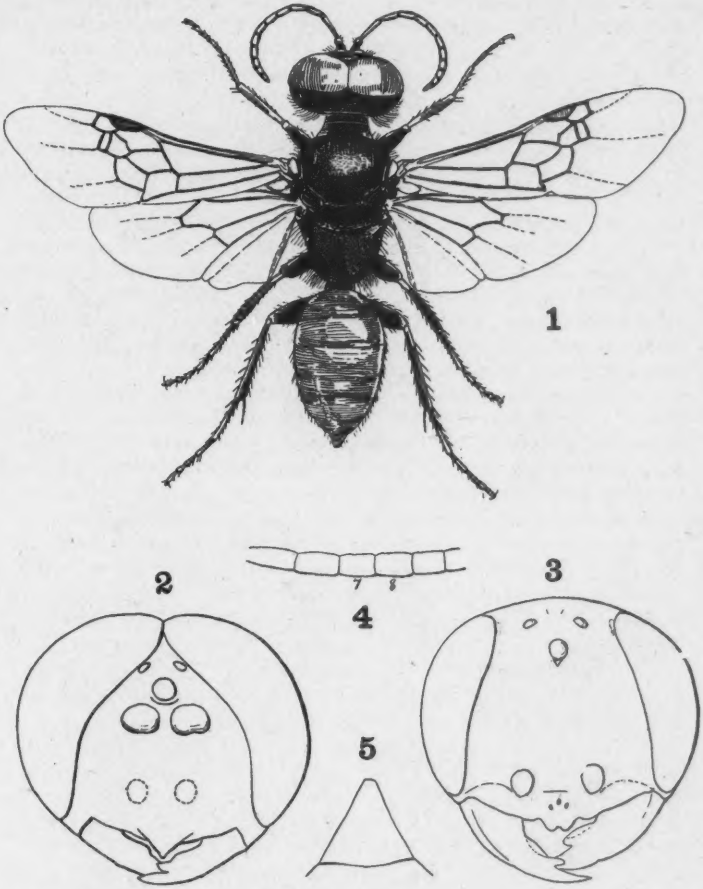
While at the Academy of Natural Sciences of Philadelphia, Mr. P. H. Timberlake of the University of California Citrus Experiment Station, Riverside, California, kindly compared specimens of the *Astata* from Honolulu, Hawaii with the type of *Astata bella* ♂ and of *Astata elegans* ♀.* Mr. Timberlake believes that the *Astata* from Hawaii—which I describe as *A. immigrans*—is different from *A. bella,* and I quote from his notes taken in Philadelphia: Comparing *A. bella* Cress., type ♂, "Cal.": "Differs from the Honolulu ♂ in having the white spots on frons extending upward each side of anterior ocellus. Eyes more broadly touching on vertex."—"Poststigmatal part of marginal cell nearly twice as long as the substigmatal part (the two parts nearly equal in the Honolulu species). The type has the tegulae and tubercles white. Wings with a faint cloud across marginal, second and third submarginal cells."

Comparing *Astata elegans* Cress., type ♀, "W.T.": "Differs from the Honolulu ♀ in having tegulae, entirely, tubercles and a spot behind tubercles, ivory-white. Median lobe of clypeus armed apically with three equal teeth. Stigma larger. Marginal cell about twice as large as in the Honolulu species, the part beyond end of stigma somewhat less than twice as long as wide, instead of as long as wide."

Astata immigrans has a very short marginal and third submarginal cell, in this respect approaching the genus *Diploplectron* Fox.

On July 18, 1939, I observed some small wasps on a large spreading plant of *Portulaca oleracea* Linn. that was growing in the hot sunshine at Ewa Plantation Company, Oahu. Most of these wasps proved to be the active *Solierella rohweri* (Bridwell), but there was also a stouter-bodied species with a red abdomen that was new to

* W. H. Patton (Can. Ent. **27** [1]:280, 1895) states: "*Astata montana,* Cress. [Syn. *Ast. elegans,* Cress., ♂ ♀; Syn. *Ast. bella,* Cress., ♂];—the three names belong to one variable species." Maidl and Klima (Hymenopterorum Catalogus, Pars 8, Sphecidae 1:22, 1939) accept Patton's synonymy. The present writer believes that more than one species is involved in this synonymy.



EXPLANATION OF PLATE XXXI

1. *Astata immigrans*, male. Length 5 mm.
2. *Astata immigrans*, male, head from in front.
3. *Astata immigrans*, female, head from in front.
4. *Astata immigrans*, male, portion of antenna, to show slight latero-ventral swellings basad on 7, 8 and 9.
5. *Astata immigrans*, female, pygidial outline.

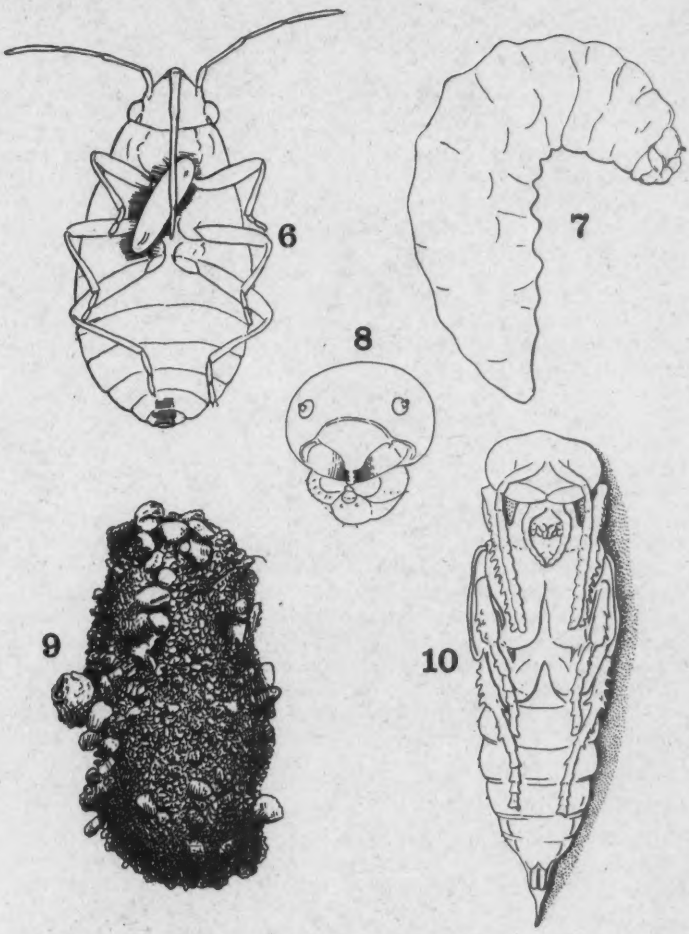
me. A half dozen of these, including both sexes in fresh condition were captured by means of wide-mouthed vials. They were determined as a species of *Astata,* and it was surprising, in my experience that insects of this genus, so wary elsewhere, could be so readily taken here.

No further attention was paid to *Astata immigrans* until June 19, 1942, when the wasps were found rather abundantly on *Portulaca* at the Experiment Station, H.S.P.A., Honolulu. The following year the first of these wasps was observed on May 22, at the same place; they continued numerous through June and July, becoming scarce by early August, although the last specimen, a male was taken on September 19. In 1944 it was first seen on June 10. On March 14, 1945 a female *Astata* was observed on *Portulaca* on the hot Waianae lowlands, and again specimens were seen on March 22, in Honolulu. The wasp is at least two-brooded here, becoming scarce or disappearing in the late fall and winter in the few acres at the Experiment Station, where their presence or absence may to some extent be regulated by the periodic destruction of *Portulaca* and other weeds there. I believe that in more favorable localities it may persist throughout the year, as does the little *Nysius* bug that constitutes its prey.

In sunny weather the male stations himself upon some stem or other convenient object from which he surveys his small world. The huge, chiefly lichen-green eyes and the shining wings make him conspicuous enough as he pivots about alertly or pursues some passing insect, to return to or near his station again. He appears to mate frequently and is often carried about by the female. The latter in her search for immature bugs creeps among the *Portulaca* stems or on the soil under the plants. Her eyes of the usual size are bluish, becoming black towards the mandibles.

It is very difficult to study the nesting activities of *Astata* in the field. She catches her relatively small prey, stings it to paralysis and is off in a flight too swift to follow. But I was rather successful in observing her activities in a large jar. In such a situation female wasps lived from 13 to 17 days.

On May 24, 1943, I placed several inches of sifted soil in two large jars, added some *Portulaca* plants, a quantity of immature *Nysius nigriscutellatus* Usinger (1942), a species of bug commonly found on this weed, and finally put in *Astata immigrans* wasps. Some days later the two wasps were observed each holding an immature bug to her breast. The nest holes were not located however, there being too much loose soil and debris about. Nevertheless, one of the two jars stocked with a single female wasp yielded a progeny of eight males and six females, between June 20 and 29. Thus the life-cycle—from egg to adult—occupied a minimum of about 26 days.



EXPLANATION OF PLATE XXXII

6. Young *Nysius* bug with egg of *Astata immigrans* glued on its breast.
7. *Astata immigrans*, large larva.
8. *Astata immigrans*, larval head, last stage, slightly inclined forward from mouth.
9. *Astata immigrans*, cocoon. Length about 8 mm.
10. *Astata immigrans*, pupa. Length 6.5 mm.

Much better results were obtained commencing June 14, 1944, when a 9″ x 15″ jar was placed on its side so that a tongue of shallow, well-packed soil extended free from the mass of *Portulaca* plants towards the mouth of the jar. Young *Nysius* bugs were added from time to time and a single male and three female wasps introduced. On June 15, a fourth female was added. The jar was kept on the laboratory counter and away from direct sunlight. The soil was but slightly moistened. The wasps' activities were observed only at irregular intervals. The male wasp by his frequent matings appeared to interfere with nesting operations, carried on by the females.

Late in the morning of June 17 a single wasp was noted excavating her burrow on the tongue of soil. She would back out dragging a load of soil with her mandibles or throw it behind her with her fore feet, so that a low inconspicuous heap was formed before the short burrow. Presently she sallied forth among the *Portulaca* plants, to return at 11:25 A.M. with a *Nysius* nymph beneath her body which she thus carried into her burrow. Other bugs were brought in at 11:40, 11:49, 11:55 A.M., and at 12:00 M. Other *Astata* were observed nesting close by. They quarrelled to some extent.

The wasp likes to search the tips of the plant for her prey; she appears little excited when a suitable *Nysius* nymph is found, but grasps it and brings her abdomen beneath and forward to sting the bug to near immobility. One of these wasps observed malaxating her prey held it beneath her, venter up, by means of her first and second pairs of legs and applied her mouth parts to its throat and leg bases. When that is finished *Astata* grips the basal portion of the bug's antennae with her mandibles, releases the leg-hold and walks or hops off with her burden, by an often circuitous route, to the nest hole which she enters headfirst. The burrow except when completely stored appears to be always left open. It is a short affair of more than one cell, and each wasp undoubtedly excavates several burrows in her lifetime.

At least one individual was engaged in nesting activities as late as June 26. On the day following I carefully dug up the main burrow area. Small groups of bug nymphs were thus exposed in some cells, and in two cases there was an *Astata* egg glued obliquely on the bug's breast. The victims could do no more than twitch their toes. In other cells were larvae spinning their cocoons, and some prepupae and a pupa in their very flimsy envelopes. A few of these early stages were preserved.

The delicate, glassy white egg is about 1.05 mm. long (fig. 6). The larva (fig. 7), at least when well grown, shows no pilosity except sparsely about the mouth region of its globular head; the body is little modified, having no lateral thoracic papillae such as occur in the Larridae, and the lateral body ridges are not conspicuous.

The pupa (fig. 10) is at first creamy white with glassy appendages; the legs are short-spined while the abdomen bears dorso-lateral spine bands. It is an active wriggler. The cocoon (fig. 9) is a fragile affair of silk and grains of soil and unless carefully taken up in its entirety is likely to fall apart.

Figure 1.—*Diploplectron* sp., ♂. San Francisco, California.

In all, twenty-three individuals of *Astata* in various stages were secured from these cells. Six males and eleven females (two of which were in a crippled condition) were hatched, becoming fully developed from July 10-14.

Observations on the biology of other species of *Astata* have been made in several parts of the world by a number of entomologists. The species of Hemiptera which these wasps favor belong to the family Pentatomidae, but they also store bugs of the families Coreidae and Lygaeidae. In the San Francisco Bay region of California, I have found a species of *Astata* with a red abdomen preying upon adult *Nysius strigosus* Uhler and nymphs of what was probably *Lygaeus bicrucis* Say.

For literature on the genus *Astata* consult Hymenopterorum Catalogus, Pars 8: F. Maidl et A. Klima; Sphecidae I. (Astatinae —Nyssonidae), 1939.

The genus *Diploplectron* Fox (Trans. Amer. Ent. Soc. Phil., **20**: 534, 1893) differs from *Astata* most obviously in the venation of the forewings, and in having the compound eyes of the male well separated at the vertex. The wasps average much smaller in size than *Astata,* and the genus has fewer species and a more limited distribution, occurring in the United States chiefly west of the Mjssissippi, and in South Africa. Further collecting will probably extend the distribution of these obscure little wasps. There may be considerable variation in wing venation among individuals of the same species of both *Astata* and *Diploplectron,* and our species need further study.

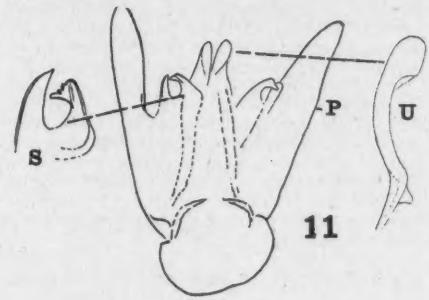
At least three species of *Diploplectron* are found in California. Two species occur in the region of San Francisco, while what may be a third species inhabits the Sierra Nevada Mountains. Southern California should yield one or more species. In San Francisco itself there is a *Diploplectron* (text figure 1) separable from a form that occurs nearby, at San Rafael, in Marin County and Menlo Park, San Mateo County, and no doubt elsewhere, chiefly in having longer antennal joints. These two insects, as far as known, inhabit different subfaunal areas.

The writer has made but scant observations on the biology of *Diploplectron.* In San Francisco, the wasp was noted chiefly during the summers of 1922 and 1930. The female *Diploplectron,* an active little polished black insect, keeps close to the ground, entering superficial holes and rummaging under debris in her search for the nymphs of *Sphragisticus nebulosus* (Fallen) (Lygaeidae), a small black bug that is found in such situations. The wasp stings her prey, grasps it by the antennae and bears it nestwards. She has the aggravating habit of hopping upgrade with her apparently heavy burden and then of disappearing in flight. The nest is dug in the sand, several bugs being stored in a cell. The egg is glued to the breast of one of these bugs. This wasp also preys upon bug nymphs of a paler color, species undetermined.

At Menlo Park, during the summer of 1937, another species of *Diploplectron* was taken preying upon an adult *Rhyparochromus californicus* Van Duzee and what appeared to be a nymph of *Emblethis vicarius* Horvath, both of the family Lygaeidae. The bug determinations were made by the late Mr. E. P. Van Duzee.

Diploplectron reticulatus n. sp. (plate XXXIII, figures 14-16)

Male, type: Length 4.8 mm. Head and thorax subopaque, abdomen shining. Black; mandibles reddish with some yellow near base, antennae brownish, paler apically, first and second pairs of legs dark brown, tarsi paler, posterior femora, tibiae and tarsi orange-red, tegulae pale brown, postnotum and propo-



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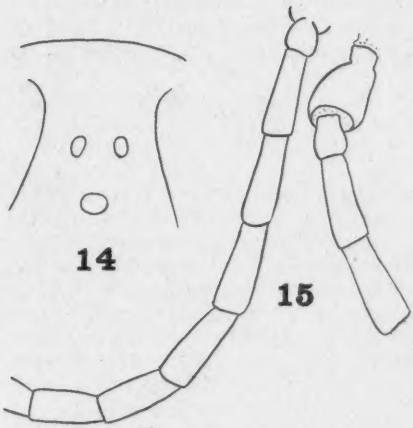

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EXPLANATION OF PLATE XXXIII

11. *Astata immigrans*, male, terminalia; P, paramere; S, volsellar plate; U, lateral plate of aedeagus.
12. *Astata immigrans*, male, ninth sternite.
13. *Astata immigrans*, male, tenth abdominal segment.
14. *Diploplectron reticulatus*, male, type, ocelli.
15. *Diploplectron reticulatus*, male, type, portion of antenna.
16. *Diploplectron reticulatus*, male, type, head.

deum with faint indications of reddish, abdomen orange-red. Head very finely reticulate; clypeus drawn out mesad as a simple narrow lobe; antennal joints 3 and 4 subequal; interocular space at vertex slightly less than joints 2 + 3; ocelli in an acute triangle; line from anterior ocellus to near clypeus not strong. Thorax very finely reticulate, except scutellum which is largely glabrous; disc of propodeum finely reticulate in a transversely wavy effect, depressed mesad apically, only a trace of marginal curved groove; propodeal pleura finely reticulate and with short oblique carinulae, this sculpture more obscure on posterior face which has a triangular fovea above. First recurrent and first transverse-cubital veins interstitial, second recurrent received in middle of second submarginal cell, third submarginal cell of usual abbreviated form, about equal in length above and below; apex of posterior wing with an infumate spot. Last visible ventral segment with the apical portion narrowed, parallel-sided, rounded and subtruncate apically.

Tucson, Arizona, May 20, 1920 (F. X. Williams). One male in fair condition.

Evidently related to *D. vierecki* Pate (Ent. News, **52**: 4-6, 1941) from El Paso County, Texas, but differs from that species in its simple, conically pointed clypeus and in its wholly reticulate mesonotum—without small, moderately close punctures.

Type to be deposited in the collection of the California Academy of Sciences.

The Occurrence of Trypanosoma conorhini Donovan in the Reduviid Bug, Triatoma rubrofasciata (Degeer) from Oahu, T. H.

By LT. SHERWIN F. WOOD H(S), USNR

(Presented at the meeting of August 13, 1945)

In 1942, C. E. Pemberton (Hawaiian Med. Jour., 2: 192) reported a large number of specimens of *Triatoma rubrofasciata* (Degeer) collected in an old lumber pile in the Kaimuki district of Honolulu. Previous studies by Donovan (Trans. Bombay Med. Congr., 1909, Feb. 24: 159), Lafont (C. R. Soc. Biol., 1912: 380-382; Ann. Inst. Pasteur, 1912, **26**: 893-922), Morishita (Japanese Jour. Zoöl., **6**: 459-546) and Bonne (Geneeskundig Tijdschrift voor Nederlandisch-Indie, 1936, **76**: 2483-2486) have pointed out the similarity of the parasites harbored by *T. rubrofasciata* to the causative agent of Chagas' disease, *Trypanosoma cruzi* Chagas.

After consultation with Honolulu entomologists, a search was made of some likely localities in the Kaimuki district May 26, 1944, by Dr. Walter Carter and the writer, but no *Triatoma* were found. Through the kindness of Dr. Carter, two male and two female *Triatoma rubrofasciata* collected by Mr. K. Ito under a chicken coop on March 27, 1945 were obtained. The insects were dead when dissected May 19, 1945 but one male and two females showed typical crithidial and trypanoform stages of *Trypanosoma conorhini* Donovan. One male collected May 24, 1945 from the davenport inside a neighbor's house was examined in Dr. Carter's laboratory on May 31, 1945 and revealed a heavy infection of the same parasite. Subsequently, Mr. K. Sakimura brought in nineteen nymphs, one male and one female from a house for cats in the Kaimuki district. All of these bugs were negative but another male and female collected by the writer with Mr. Ito in the same general area from under a chicken coop were heavily infected.

The structure of these parasites from stained smears and the characteristic motility of the trypanoform stages agree very closely with previous studies of the crithidial and metacyclic trypanosome forms of *Trypanosoma cruzi* harbored by *Triatoma protracta, T. protracta woodi, T. rubida, T. gerstaeckeri,* and *T. longipes,* in the United States.

The writer is indebted to Mr. Ed. Mau, in charge of the Plague Laboratory, for permitting use of laboratory facilities in maintaining the insect cultures.

New Usingerius from the Philippines and Borneo (Coleoptera: Curculionidae)

By ELWOOD C. ZIMMERMAN
Bernice P. Bishop Museum, Honolulu

(Presented at the meeting of November 19, 1945)

The anthonomine genus *Usingerius* was described to receive its genotype, *U. maculatus* Zimmerman from the island of Guam (Bishop Museum Bull. **172**:94, 1942). It is of considerable interest to be able now to record two new forms, one from the Philippines, the other from Borneo, thus removing another monotypic genus from the lists. Moreover, the new zoogeographical data are worthy of being added to the published record.

Usingerius has no tibial mucrones, the antennal funiculi are six-segmented, the tarsal claws are deeply cleft, the femora are toothed, the eyes are large, protuberant, close together above, and the vestiture of the dorsum of the body consists of prostrate squamules.

Usingerius rubens, new species (fig. 1, *a;* fig. 2, *a, b*)

Female. Derm reddish brown, appendages paler reddish brown to brownish yellow; dorsal vestiture white everywhere except where there are some irregular and probably variable areas of dark, bronzy squamules; vestiture of appendages and under surfaces white.

Head with crown obviously depressed below level of eyes and slightly below interocular area, reticulate, minutely punctate, lanceolate squamules similar to those on pronotum, not concealing derm; interocular area about one third as broad as an eye as measured from above, derm concealed there by condensed squamules.

Rostrum, measured along its chord from dorsal apical margin to a point beneath anterior edge of an eye, as long as breadth of pronotum, evenly arcuate; with carina at middle, at dorsal margins of scrobes and one between these on sides distinct, the four grooves between these five carinae distinctly setose; antennae inserted at one fourth distance from middle to apex beyond middle; area beyond antennae shiny and minutely punctate.

Antennae with club of scape about as long as first antennal segment; first funicular segment as long as II plus III, segment II about as long as III plus IV, V and VI each slightly broader; club somewhat longer than preceding six funicular segments, joints between two basal segments deeply and distinctly marked.

Prothorax one fourth broader than median length to apex of prescutellar lobe, broadest at about middle; base shallowly concave on either side of prescutellar lobe; sides convex from base to beyond middle, thence concave to apex; subapical constriction continued across dorsum, the longitudinal outline of which is sinuous, basally convex, reaching its maximum height near middle and obviously discontinuous with longitudinal dorsal contour of elytra; densely, moderately coarsely punctate; squamules rather coarse, sublanceolate, decurved, mostly well separated, densest on prescutellar lobe and there concealing derm, also more condensed on sides in subapical constriction.

Scutellum convex, clothed with fine, appressed squamules.

Elytra about three fourths as broad as long, about three and one half times as long as side of prothorax (measured from side, prothorax from front to humerus, elytra from humerus to apex), nearly straight on sides from broadly rounded humeri to near middle, thence arcuate to apex; striae well defined; intervals broad, convex, minutely roughened and punctate; squamules similar to, but somewhat smaller and more appressed than those on pronotum, directed caudad and not echelon-like.

Legs rather loosely clothed with prostrate hairs; femora with teeth strongly developed throughout; fore femoral tooth almost forming an equilateral triangle, nearly as high as subapical breadth of a tibia; tibiae strongly sinuous on inner side, anterior pair almost twice as broad at about middle as subbasally.

Sternum hirsute; prosternum with coxae so close together that vestiture of two coxae touches; metasternum with a median fovea behind, about as long at its narrowest point between mid and hind coxae as length of first ventrite behind a coxa; pleura squamulose.

Abdomen with ventrites finely punctate, hirsute, finely so on their disks, more coarsely laterad, the finer hair more slanting or suberect, the coarser hair or setae more prostrate; pygidium concealed.

Length (excluding head): 2.7 mm.; breadth: 1.4 mm.

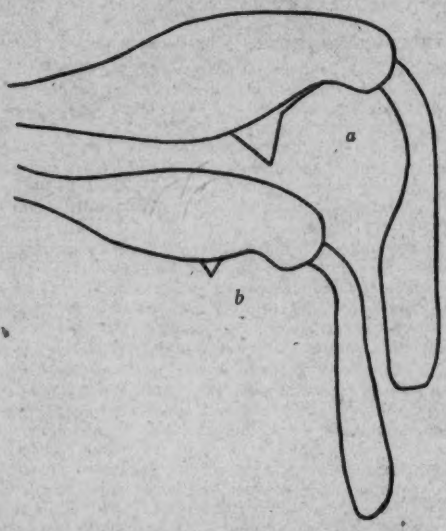

Figure 1.—Sketches of fore femur and tibia of *a, Usingerius rubens* Zimmerman, and *b, Usingerius rubens parvidens* Zimmerman.

Philippine Islands. Holotype female (United States National Museum, number 57243) collected by the late C. F. Baker at Dapitan, Mindanao (bearing the number 4477).

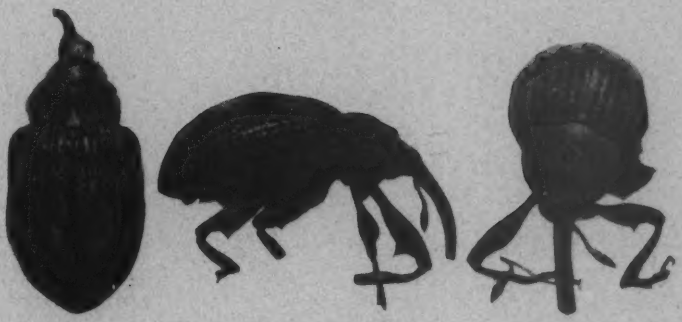

Figure 2.—New *Usingerius*. *a*, dorsal, and *b*, lateral views of *Usingerius rubens* Zimmerman. *c*, *Usingerius rubens parvidens* Zimmerman. (Photographs prepared at the U. S. National Museum, and reproduced through the courtesy of L. L. Buchanan.)

This species differs specifically from *Usingerius maculatus* in a number of ways, some of the most salient of which are as follows: it is somewhat larger, proportionately broader, the vestiture is white instead of predominantly golden or yellowish, and the elytral squamules, in addition to being distinctly coarser, are all directed caudad instead of those along the middles of the intervals being directed caudad while those on either side are directed obliquely toward the median line as on *U. maculatus*.

Usingerius rubens parvidens, new subspecies (fig. 1, *b;* fig. 2, *c*)

With the specimen described above, a single individual from Borneo also was sent to me for description. This second specimen is closely similar to typical *rubens,* but it cannot be assigned to that form because of certain distinctive features. A series of specimens might furnish additional information that will show that the forms are specifically distinct. However, with the inadequate material now at my disposal, I believe that it is best to consider this example as representing a geographical subspecies.

The description of *rubens* will apply almost in every way to this form excepting in the following particulars: The abdomen is typically feminine, with the pygidium concealed, and I believe the specimen is a female. However, the rostrum is more masculine, it is not as long as the breadth of the pronotum, the antennae are inserted at about the distal third, and the dorsal area beyond the insertion of the antennae is more coarsely punctured. The femora are not so heavy, and the teeth are obviously smaller. The tooth on the fore femora is only half as long as the breadth of a fore tibia. The fore tibiae are quite differently shaped, they are not nearly so sinuous along their inner edges, are not broadened submedianly as on *rubens,* and their submedian breadth is obviously less than twice as broad as the subbasal breadth. The differential characters of the legs can best be appreciated by examining the diagrams.

Length (excluding the head): 2.25 mm.; breadth: 1.25 mm.

Borneo. Holotype female (?) (United States National Museum, number 57244), collected by C. F. Baker at Sandakan, British North Borneo (bearing the number 15039).

Browne 1887, not Douglas 1888, the Author of Orthezia insignis (Homoptera: Coccoidea)

By ELWOOD C. ZIMMERMAN
Bernice P. Bishop Museum, Honolulu

(Presented at the meeting of November 19, 1945)

During a research trip to the mainland in 1940 while preparing manuscript for the forthcoming manual "Insects of Hawaii," I had an opportunity to check the original descriptions of various insects in journals not available at many institutions. This work in the nation's finest entomological libraries resulted in some rather unexpected results which will be published later, but it has been suggested that the case involving the common pest species, the greenhouse *Orthezia*, should be brought to light now. Hence, this note is presented here.

In August 1887, E. T. Browne read a paper to the Quekett Microscopical Club, and in series 2, vol. 3, pp. 169-172, plates 16-17, December, 1887 his paper was published in the society's "Journal" under the title "Notes on a Species of Orthezia found in Kew Gardens." In this paper he described and figured *Orthezia insignis*. This is the original description of the species, although I have never seen it credited to any author other than Douglas. The paper prepared by J. W. Douglas, however, "Note on Some British Coccidae," The Entomologist's Monthly Magazine, 24: 165-171 (the number for December, 1887) was not published until January 1888. Some authors have credited the species to Douglas and have cited the Journal of the Quekett Microscopical Society, 1887, as the reference, although that paper was written by Browne.

I have called this problem to the attention of Dr. Harold Morrison, who has also checked the matter carefully and has discussed it with Mr. C. F. W. Muesebeck. These workers agree with the conclusion that Browne is the author of the species. Dr. Morrison has kindly forwarded the following pertinent data:

Browne evidently studied his Kew Gardens discovery, going to the extent of looking up pertinent literature and comparing the insects with specimens in the British Museum. His paper contains a number of descriptive items, noted as characteristic of the genus *Orthezia*, but plainly based on his observation of this particular species. His comments on and figures of the adult male obviously are in error, almost certainly based on a Pseudococcine male. Browne quotes a communication from J. W. Douglas expressing his (Douglas') opinion that the insect is new. At no point in the text is the name *insignis* mentioned, nor are any claims made that the author (Browne) is attempting to describe a new species. However, in explanation for Plate XVI the following notation is made: "Fig 1. *Orthezia insignis*, male, x 30 diam." and this is followed immediately by "Fig. 2, *Orthezia insignis*, female, x 30

diam." . . . The error in attributing to *Orthezia* the male characterized by both Douglas and Browne was soon discovered and corrected in print by Mr. E. E. Green.

What has happened, it appears, is that Browne "scooped" Douglas in describing the species, although he did not do so intentionally. Browne was apparently more intent upon describing the habits of the species than naming it as a new insect, as indicated in the following statement by Douglas (1888, p. 171): "In August Mr. Edward T. Browne, Unbridge Lodge, Shepherd's Bush, sent me several examples of this species, which he had obtained in the Royal Gardens at Kew, requesting that I would describe it if new, . . ." However, it is essential to have certain basic technicalities to make for stability in nomenclature, and according to the rules of zoological nomenclature Browne first described, figured and gave a name to the species. The credit belongs to him, and the species should be known as *Orthezia insignis* Browne.

A Remarkable New Pseudopsectra from Maui (Neuroptera: Hermerobiidae)

By ELWOOD C. ZIMMERMAN
Bernice P. Bishop Museum, Honolulu

(Presented at the meeting of December 10, 1945)

Flightless derivatives of volant native insects are always fascinating objects of study. Herein is presented the description of *Pseudopsectra cookeorum*, one of the finest and most spectacular of all of the known Hawaiian Neuroptera. Its discovery gives further weight to the opinion that a whole series of such local, aberrant offshoots of the large Hawaiian genus *Nesomicromus* remain to be discovered by diligent collecting. The evolutionary processes which are responsible for the origin of this unusual creature have created a flightless, spinose "monster" whose salient characters are unique among its known allies.

Pseudopsectra cookeorum, new species (fig. 1)

Derm mostly glistening, appearing as if wet, basically brownish yellow marked with fuscous and piceous; head and antennae nearly concolorous, spines on crown darker; thoracic nota similarly colored, but pronotum tending to be darker on side margins; legs with femora somewhat clouded, fore and mid tibiae rather obscurely darkly biannulate; venter of abdomen yellowish apically but becoming darker basad; fore wings with entire margin with subequally spaced dark marks which make an alternating dark and pale marginal pattern, main veins with variable and irregular dark maculae.

Head with face shiny, but derm shallowly punctate, minutely alutaceous, finely hirsute; crown irregularly protuberant, asperate, setose, conspicuously spinose, the spines bipartite, each consisting of an elongate, heavy, rod-like base from the apex of which arises a strong, acuminate seta; antennae about as long as greatest chord of a fore wing; terminal segment of maxillary palpus about twice a long as penultimate, flattened, lanceolate-acuminate; distance across eyes, as seen from front, equal to length of pronotum plus about one half of crown.

Thorax with pronotum about one sixth broader than long, surface roughened by small tubercle-like bases of numerous, bipartite, short spines, and dorsum bristling with conspicuous, large, bipartite spines similar to but larger than those on crown, the larger of these fully as long as diameter of an eye (about 0.25 mm.), these large spines confined to the three transverse, lobe-like zones on dorsum, posterior zone with one spine on either side of median line, median zone with five to seven large spines on either side, anterior zone with about nine to twelve spines; median line of disk well defined anterior to basal zone, free from large spines and separating the median and anterior zones into halves; mesonotum with similar small and large spines, and with about four or five large spines on either side, metanotum with only a single pair.

Wings with fore pair shaped as illustrated, venation as illustrated, about twice as long as broad, hind (dorsal) margin continuously arcuate, thick,

entirely coarsely reticulated by a network of multitudinous, coarse, cross-veins all armed with small, bipartite spines, and marginal veins, main veins and their principal branches armed in addition with large, very conspicuous bipartite spines as on head and thorax, but some of them larger (some 0.4 mm. long); hind wings minute, easily overlooked fleshy flaps about 0.1 mm. long, evidently veinless.

Legs with fore and mid femora and tibiae bristling with spines and setae, hind pair setose but with fewer spines.

Abdomen moderately shiny; conspicuously setose, the setae arising from distinct basal granules.

Length (wings closed against body, measured from front of head to apex of wing): about 4 mm.; expanse: about 7.5 mm.

Island of Maui, Territory of Hawaii. Holotype male and allotype female beaten by me from *Dubautia* growing on the steep slope just inside the rim below the summit of Haleakala Crater at about 9700 feet elevation on April 25, 1945.

It is with much pleasure that I dedicate this remarkable indigene to my close friends, Dr. and Mrs. C. Montague Cooke, Jr., whose kindness and interest in my work made possible my 1945 collecting trip to Maui.

In my "Studies of Hawaiian Neuroptera" (Proc. Hawaiian Ent. Soc. **10** [3] : 487-510, 1940), two species were added to the then monotypic *Pseudopsectra,* and it was pointed out that with the discovery of the new species the gap between *Pseudopsectra* and *Nesothauma* had been reduced. This new species further reduces that gap. The prominent spines on the fore wings, thorax and head are distinctive, but these, remarkable as they are, are only relatively spectacular developments of the fine hairs or setae of our other hemerobiids. The pronounced reticulate pattern formed by the veins and cross-veins in the fore wings is shared by other species, especially by *P. swezeyi.*

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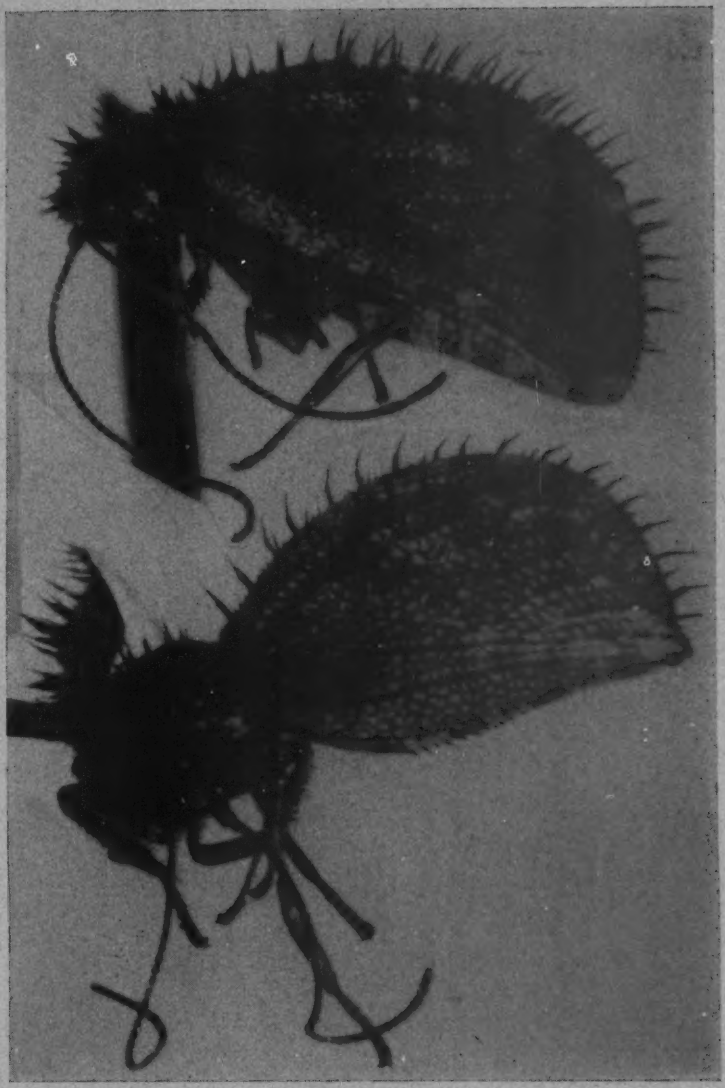

Figure 1.—**Pseudopsectra cookeorum** Zimmerman, new species. Male holotype (upper figure) and female allotype. (Photographs by J. T. Yamamoto, courtesy of the Hawaiian Sugar Planters' Experiment Station.)

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Species marked with an asterisk were reported in the Hawaiian Islands for the first time in 1945, on the dates recorded in the text. Those not so marked were observed here prior to that year, but have only now been identified. For particulars refer to the pages indicated.

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ERRATA, VOLUME XII

Page 2, line 9, for *"Gynandropis"*, read *"Gynandropsis"*.
" 22, lines 1 and 2, for *"Hawaiiana"*, read *"Hawaiina"*.
" 22, line 32, for "1942", read "1943".
" 24, line 18, for *"Aelothrips"*, read *"Aeolothrips"*.
" 31, next to last line, for *"hawaiiensis"*, read *"oahuensis"*.
" 59, line 11, for "activly", read "actively".
" 70, column 5, line 7 from bottom, for *"ipomoea"*, read *"ipomoeae"*.
" 83, line 12, *"Corizus hyalinus"* should be under a separate heading reading "Coreidae".
" 83, line 12, the heading "Lygaeidae" should immediately precede *"Geocoris"* and *"Orthaea"*.
" 83, line 15, for *"Orthoea"*, read *"Orthaea"*.
" 84, line 6 from bottom, for *"Hypochaeris"*, read *"Hypochoeris"*.
" 93, line 13, for *"purpurifera"*, read *"purpurifer"*.
" 108, line 4, for "firewood", read "fireweed".
" 113, line 24, for *"Hypochaeris"*, read *"Hypochoeris"*.
" 143, line 17, for *"anastamosalis"*, read *"anastomosalis"*.
" 153, line 8 from bottom, for *"Bilbergia"*, read *"Billbergia"*.
" 188, line 8 from bottom, for *"vagans"*, read *"mulsanti"*.
" 189, line 4 from bottom, for *"Hydrodyction"*, read *"Hydrodictyon"*.
" 207, line 10, for "Palao", read "Palau".
" 225, line 7 from bottom, for *"unicinctus"*, read *"uncinatus"*.
" 226, line 2, for *"unicinctus"*, read *"uncinatus"*.
" 246, middle of page, for "Thorrel", read "Thorell".
" 257, line 2, for "is", read "in".
" 311, line 2, for *"lacrymae-jobi"*, read *"lacryma-jobi"*.
" 340, line 9m for *"Corchoros"*, read *"Corchorus"*.
" 346, line 15 from bottom, for *"Stauropis"*, read *"Stauropsis"*.
" 350, line 15, for *"Apotomorrhinus"*, read *"Apotomorhinus"*.
" 364, line 19, for *"Negata"*, read *"Negeta"*.
" 393, line 19, for *"Hercothrips"*, read *"Hercinothrips"*.
" 398, line 7 from bottom, for "Phisia vaureum Guen.", read "Plusia v-aureum Guen.".
" 400, line 15, for *"Epipogium"*, read *"Epipogum"*.
" 401, line 13, for *"tibicinus"*, read *"tibicinis"*.
" 402, line 5, for *"mucifera"*, read *"muscifera"*.
" 409, 2nd line of legend for fig. 2, for "right", read "left".
" 424, next to last line, for "26", read "16".
" 461, line 5 from bottom, for *"Anophothrips"*, read *"Anaphothrips"*.
" 461, last line, for *"unicinctus"*, read *"uncinatus"*.
" 482, last line, for *"kaalense"*, read *"kaalaense"*.
" 599, line 26, for *"Psylliodis"*, read *"Psylliodes"*.

ERRATA NOT PREVIOUSLY NOTED

Vol. VIII, p. 135, line 9, for "VI", read "IV".
" X, p. 46, line 10 from bottom, for *"Aplothrips"*, read *"Haplothrips"*.
" X, p. 97, heading of Plate III, for "Vol. I", read "Vol. X".
" X, p. 116, " " " IX, for "Vol. V", read "Vol. X".
" X, p. 125, " " " X, for "Vol. V", read "Vol. X".
" X, p. 129, " " " XI, for "Vol. V", read "Vol. X".
" X, p. 198, line 8 from bottom, for *"nymphae"*, read *"nymphaeae"*.
" X, p. 264, line 3 from bottom, for *"nymphae"*, read *"nymphaeae"*.
" X, p. 496, *Anomalochrysa angulicosta* Perkins was omitted from the key. At "17(16)" read as follows for the first paragraph:

"Anterior wing membrane whitish, and/or with all the cells distinctly infuscate along the veins; Oahu and Molokai .....17a"

Then insert the following:

"17a(17). Fore wings with dividing vein of third cubital cell joining M at or near distal side of cell so that distance between the vein and distal side of cell is obviously much shorter than length of dividing vein; costal margin of male not angulate; Oahu.....*cognata* Perkins.

Fore wings with dividing vein of third cubital cell joining M at a distance from distal side of cell so that distance between the vein and distal side of cell is about equal to length of dividing vein; costal margin of male conspicuously and unusually angulate at about eleventh or twelfth cross vein from base; Molokai.....*angulicosta* Perkins".

" X, p. 502, line 14, for "1925", read "1935".
" XI, p. 9, par. 3, line 2, for "published as No. 32", read "published as Occasional Papers, Vol. 15, No. 23".
" XI, p. 71, heading of right-hand column, for "Major Insects", read "Minor Insects".
" XI, p. 161, line 10, for "afternon", read "afternoon".
" XI, p. 256, line 12 from bottom, for *"nymphi"*, read *"nymphaeae"*; for "Sulzer", read "(Sulzer)".
" XI, p. 261, last par., line 1, for "Wied.", read "(Wied.)".
" XI, p. 298, line 16, for "ben", read "been".
" XI, p. 301, line 24, for *"Pethrochroa"*, read *"Petrochroa"*.
" XI, p. 302, last line, for "bettles", read "beetles".
" XI, p. 310, line 5 from bottom, for "Handel", read "Hendel".
" XI, p. 311, line 2, for "Handel", read "Hendel".
" XI, p. 315, line 5 from bottom, for *"Dicranomyia"*, read *"Libnotes"*.
" XI, p. 318, line 16 from bottom, for *"Dicranomyia"*, read *"Libnotes"*.
" XI, p. 320, lines 4 and 11 from bottom, for *"Dicranomyia"*, read *"Libnotes"*.
" XI, p. 342, par. 2, line 2, for *"Lucaena"*, read *"Leucaena"*.
" XI, p. 350, in figure 1, the drawing to the left of "b" should be labeled "d".
" XI, p. 361, col. 1, line 16 from bottom, for *"nymphi"*, read *"nymphaeae"*.
" XI, p. 364, col. 1, line 15 from bottom, for "sambuc", read "sambac".